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AMERICAN WELDING SOCIETY
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ANNUAL MEETING

Plans are already under way for making the coming annual meeting of the Society, which will be held on April 25, 26 and 27, the most successful in the history of the Society. The next issue will contain a tentative program of this meeting. Every member is urged to arrange his plans so that he can attend on the above mentioned days.

There will be technical sessions, reports of the Committees on Pressure Vessels and Structural Steel, the annual business meeting of the Society, annual dinner, and the annual meeting of the American Bureau of Welding.

PRESSURE VESSELS

The program of the proposed Pressure Vessel Investigations, approved at the last meeting of the Joint Pressure Vessel Committee of the American Society of Mechanical Engineers and the American Bureau of Welding, has been sent out to some 500 tank manufacturers.

Cooperation is being solicited to make this investigation one of the greatest carried out by the Society. All types of tanks most commonly used in commercial work will be tested to destruction by hydrostatic pressure and by breathing tests. There will also be tensile, bend, shock and fatigue tests of coupons. Any tank manufacturer who did not receive a copy of the program and who desires to cooperate in this work should communicate at once with the Society.

INSTRUCTION MANUALS

Fundamental information for the training of student welders and engineers in arc, gas, resistance and thermit welding are now available. These bulletins of information have been compiled by the Educational Committee of the American Welding Society. They may be obtained from the Society headquarters at 50c. each (Resistance Course 35c.). The courses will be bound together in permanent book binding and made available at $2.50 per volume.

MEMBERSHIP ACTIVITIES

The Membership Committee of the American Welding Society has given a great deal of consideration to the necessity of enlarging our membership in order to increase the sphere of usefulness of the Society, its prestige and revenue. One of the plans adopted is to compile carefully a large list of prospective members for the Society. These prospective members, starting with this issue of the JOURNAL, will receive three consecutive copies of the JOURNAL without charge; each JOURNAL being accompanied by an appropriate membership letter. At the end of the three month period they will be requested to join the Society, and if they do not, of course their names will be stricken from the list of prospective members and new names added.

Every member of the Society is urgently requested to cooperate in this plan by sending from one to five names of *real* prospective members, together with their addresses, in order that they may be placed on this list.

OBITUARY

Death came suddenly to John Seneca Ely on the evening of Dec. 15, 1927, at his late residence, 103 West Seventy-seventh Street, New York City.

Mr. Ely was born in Attleboro, Pa., Aug. 17, 1858. His father, John Ely, was a well-known merchant in Philadelphia and vicinity prior to the Civil War and during the latter part of the Civil War was Major General of Volunteer Troops.

Mr. Ely attended Smith's Academy at Doylestown, Pa., and Lafayette University, Easton, Pa. He served

an apprenticeship in the plant of the Phoenix Iron Works, Phoenixville, Pa., and shortly thereafter entered the employ of the Philadelphia Traction Company, finally becoming chief engineer of that organization and consultant for street railways in New York, Baltimore, Washington and Pittsburgh. During the years 1895 and 1896, he was mechanical engineer for the Charleston Mining & Manufacturing Company, Charleston, S. C., after which he became operating engineer for the Schuylkill Valley Illuminating Company of Phoenixville, Pa. Later he was mechanical designer for the New York Central & Hudson River Railroad. In the year 1909, he entered the Way Department of the Third Avenue Railway of New York, for which department he was superintendent of welding at the time of his death.

Mr. Ely was a member of the American Welding Society and the American Electric Railway Association. He was greatly interested in the science of welding as applied to street railway construction and maintenance, and carried on considerable research work, in connection with which he was frequently in touch with the Bureau of Standards, Washington, D. C. Mr. Ely has served as a member of the executive committee of the New York Section of the American Welding Society since 1925. He has taken an active interest in the affairs of the Section and has been a large contributor to its success.

DELINQUENT MEMBERS

Through a recent ruling of the Board of Directors delinquent members of the American Welding Society are to be carried on the roster of membership for six months. During the first two months they will receive copies of the JOURNAL, together with other literature. At the end of the two month period, unless they pay their dues, they will no longer receive the JOURNAL. At the end of the six months they will be dropped entirely from the membership list.

BOUND VOLUMES

Bound Volumes of the JOURNAL are now ready for the year 1927. These may be purchased from the Society at $5 per volume. They are bound in permanent book form with imitation leather covers. The volume also contains a Subject and Authors' Index. The JOURNALS for the year 1927 contain some of the best papers ever published in the welding field. They include also complete training courses for Electric Arc, Gas, Resistance and Thermit Welding.

MAKING THE APPROACH TO RESEARCH*

Given "the will to investigate" and the appropriation to proceed, how can a public utility management begin work? Here is a company, for example, which has never acquired a reputation for originality but which has made money by adhering strictly to routine. What can be done along creative lines once the idea that research is worth while has been "sold" to the management?

Rome was not built in a day, and a competent and effective research organization cannot be developed at once on systems where collateral problems have been put aside for years under the pressure of establishing or maintaining service. The first task is to define what is meant by research in a particular property or group of utilities under common management. In most cases what is meant might be called an exhaustive engineering or economic investigation of outstanding main and collateral problems bearing upon the financial or technical success of the enterprise. The inquiry may begin in an effort to locate and remove the cause of various operating troubles or economic wastes. This must, of course, be done in the ordinary course of management, but in conducting a true engineering research into the particular subject those in charge of the work will do a more thorough job than under the old régime. Care will be taken to compile and preserve data and observations in proper form for future use, the limitations of instrumentation will be recorded, photographs and drawings will be suitably filed and referenced, and time will be taken for expert comment and report formulation.

A most important part of this kind of work is the listing of collateral inquiries growing out of the major problem attack and their disposition.

*Reprinted from *Electrical World*, Dec. 24, 1927.

Here the engineer with research ability finds a wealth of opportunities for work contemporary with the main investigation or to be taken up at a definite future date. It is not to be expected that multiple engineering researches will be under way at all times on particular operating properties, but that whatever is done must be done thoroughly, leaving nothing of primary importance to memory and overlooking no possible opportunities to mark out further lines of progress. There is literally no limit to the possible number of research topics on any system of the complexity of a modern generating or transmission company, but however the beginning may be made, the cardinal point is to work in the scientific spirit. Nothing grandiose should be contemplated, but the effect of even a single piece of real research work—whether in "pure" or applied science—is so stimulating to men and women of true vision that even very humble beginnings may mean throwing new light upon routine activities.

GAS PRODUCTS ASS'N MID-WINTER MEETING

The Midwinter Meeting will be held at the Palmer House, Chicago, Jan. 26, 27 and 28, 1928.

A very interesting program has been arranged including such speakers as: Mr. Bernard J. Mullaney, vice-president of the Peoples Gas Light and Coke Company; Mr. R. A. Witherspoon, vice-president and general manager of the Canada Carbide Company; Mr. C. A. Crawford and Mr. J. G. Schoener of the International Nickel Company; Mr. P. L. Cummings, plumbing engineer, Handley & Company, plumbing contractors; Mr. J. G. Hart, general manager of the North Shore Gas Company at Waukegan, Ill.; Mr. John J. Kutsheid, Kutsheid Manufacturing Company, Chicago, manufacturers of shears, bending brakes, etc. On Friday evening there will be a theater party and on Saturday evening an informal dinner. All hotel reservations should be made through Mr. Stuart Plumley, secretary and treasurer.

WELDED ROOF TRUSS TESTED

That electric arc welded roof trusses will safely withstand the stresses for which they are designed was demonstrated by tests conducted at the American Bridge Company's plant in Trenton, N. J., on Friday, Dec. 16. At that time a live load double that for which the truss was designed was placed on the truss with satisfactory results.

The general plan for a welded roof truss, as recently announced, was prepared by William Dalton of the General Electric Company, from which a number of trusses of varying lengths and loads were designed and built by the American Bridge Company for the tests. It is claimed that a welded truss can be built with less metal and at less expense than the riveted type for the same load and span.

In testing the trusses at Trenton for their ability to withstand the load for which they were designed, three trusses of 58-foot span each were used. These were set up in the plant yard, parallel to each other the same as in a building and in such a way that, when loaded, the center truss would carry the load. Deflection readings were taken by means of a fine piano wire held at the ends of the truss and kept taut, a scale graduated in tenths of an inch being used with a mirror to show the deflection under load.

The first readings were taken when a point was reached where the load was equivalent to the normal load for which the truss was designed, and these readings showed a deflection of 0.52 inches. When the truss was carrying double live load the reading was 0.78 inches. At no time was there any indication of weakness in the structure and the engineers present expressed satisfaction with the results obtained.

The normal live load for which the truss was designed was 30 pounds per square foot of total roof surface. As tested, a load was applied equivalent to full dead load plus 60 pounds live load per square foot of total roof surface.

Among those who witnessed the tests in Trenton were: J. H. Edwards, chief engineer, and A. C. Funk, manager, Trenton plant, American Bridge Company; F. T. Llewellyn, U. S. Steel Corporation; Professor C. Gunther, Stevens Institute of Technology; W. L. Chewning, U. G. I. Contracting Company; Messrs.

Harris and Richards, architects; John Condon, Turner Construction Company; F. E. Schmitt, Engineering News-Record; W. Spraragen, American Welding Society; K. H. Condit, American Machinist; M. G. Farrell, Mill & Factory Illustrated; F. P. McKibben, consulting engineer; C. W. Bryan, Federal Shipbuilding & Dry Dock Company; William Dalton and J. D. Wright, General Electric Company.

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R. D. Thomas	1—C
J. W. Baldwin	1—D
V. M. Goode	1—D
M. Haines	1—D
Ernest Lunn	1—D
E. Norris	1—D
R. J. Petty	1—D
A. G. Watson	1—D
J. A. Wilson	1—D
T. A. Wry	1—D
A. F. Dyer	1—F
H. N. Ewertz	1—F
A. G. Odell	1—F

SECTION ACTIVITIES

Portland

One of the most successful meetings of the Portland Section was held on Dec. 16. Mr. J. F. Lincoln, vice-president and general manager of the Lincoln Electric Company, presented an address on the progress being made in welding and illustrated his remarks by blackboard sketches. To this meeting were invited engineers, contractors, manufacturers, inspectors, building owners and everyone interested in the art of welding. The discussion was spirited and the meeting finally adjourned at a late hour.

San Francisco

The San Francisco Section had a very successful meeting on Dec. 12. Mr. Lincoln of the Lincoln Welding Company of Cleveland, who was in San Francisco on business, spoke on "Application of Arc Welding to Replace Castings and Riveted Structures."

Cleveland

The following is a list of coming meetings of the Cleveland Section and the speakers at each meeting.

Jan. 12—Mr. R. K. Randall
Mr. A. F. Davis

Feb. 9—Mr. R. K. Randall
Mr. M. H. Turner

Mar. 8—Mr. A. F. Davis
Mr. O. J. Borneman

Apr. 12—Mr. M. H. Turner
Mr. O. J. Borneman

May 10—Mr. R. K. Randall
Mr. O. J. Borneman

Philadelphia

The regular monthly meeting of the Philadelphia Section will be held on Jan. 16, at 8 o'clock in the auditorium of the Engineers Club, 1317 Spruce Street, Philadelphia. Mr. D. M. Petty, electrical engineer, Bethlehem Steel Company, will address the meeting on "Applications of Welding in the Steel Industry."

Chicago

The Chicago Section held a very successful meeting on Jan. 6. The last two reels of "The Story of Steel," motion picture loaned by the United States Steel Corporation, were shown. The speaker of the evening was Mr. C. H. Hollup, vice-president of the C. H. Hollup Corporation of Chicago. The title of his address was "Arc Welding as a Factor in the Fabrication of Iron and Steel." His address was illustrated by lantern slides.

Boston

Nearly 300 members of the Affiliated Technical Societies of Boston and their guests were present at the morning, afternoon and evening sessions of the Welding Meeting held on Dec. 14, 1927, by that organization. The morning session, held in Chipman Hall, Tremont Temple, was devoted principally to structural welding, with an introductory paper by F. M. Farmer, president, American Welding Society, New York, on "General Principles of the Various Welding Processes." This paper was followed by papers on "Examples of Arc-Welded Steel Construction," by Gilbert D. Fish, consulting engineer, Westinghouse Electric & Manufacturing Company, New York, and "Welding Trusses for Industrial Buildings," by Andrew Vogel, General Electric Company, Schenectady, N. Y.

The luncheon and the afternoon session, at the Boston City Club, were held jointly with the New England Water Works Association, one of the member organizations of the Affiliated Technical Societies of Boston. The program of the afternoon session, which was devoted principally to pipe welding, included the following papers:

"Pipe Line Welding from the Oxy-Acetlyene Viewpoint," Le Roy Edwards, Industrial Engineering Dept., Air Reduction Sales Company, New York.

"Pipe Welding and Other Recent Developments in Welding," D. H. Deyoe, Industrial Engineering Dept., General Electric Co., Schenectady, N. Y.

"Thermit Pipe Welding," Robert L. Browne, New York and New England District Sales Manager, Metal & Thermit Corp., Boston, Mass.

"Replacing Castings by Steel Elements Cut to Shape by Automatic Shape Cutting Machines," Dr. A. Krebs, treasurer, General Welding & Equipment Co., Boston.

"The Metallurgy of Welding Wire," C. A. McCune, Director of Research, American Chain Company, Bridgeport, Conn.

At 6.30 p. m. the Informal Dinner and Smoker was held at which Col. Lewis E. Moore, chairman of the Affiliated Societies of Boston, presided. The evening session at the Boston City Club included the following papers:

"Unit Stresses and Reliability as Applied to Structural Welding," Fred T. Llewellyn, representing the American Society of Civil Engineers on the Joint Structural Welding Committee.

"Applications of Projection and Multiple Welds," Thomson Electric Welding Company, Lynn, Mass.

"Reclaiming a Cast Iron Waterwheel Casing," C. W. Babcock, Sales Engineer, Westinghouse Electric & Mfg. Co., Boston.

"Atomic Hydrogen Welding Process," P. Alexander, Research Engineer, Thomson Research Laboratory, General Electric Co., West Lynn, Mass.

An unusual feature of this meeting was the expeditious manner in which the twelve papers were presented, each session closing in strict accordance with the time schedule and yet allowing ample opportunity for discussion.

All aspects of welding were covered by the papers, including a description of the various welding processes and actual applications to typical jobs.

An exhibit was held at the City Club, in connection with this meeting, which included welding apparatus and specimens of welded material.

Welding Trusses for Industrial Buildings*

By ANDREW VOGEL†

THE assembly of steel members into the form of trusses and frames involves two fundamentally different types of fastenings; namely, pins and welding. The pin type fastenings can be separated into three kinds—pins, bolts and rivets. The welding method can be divided into three distinct types—mechanical, resistance and fusion welding. In this talk fusion welding alone will be discussed, with particular reference to electric arc welding. It will be understood, therefore, that in using the term "welding" the speaker is definitely confining himself to that form of welding which consists of striking and maintaining an electric arc between two electrodes, one electrode being a metallic rod and the other being the junction point of two surfaces to be connected. The metallic rod is melted away and deposits a fillet between the two surfaces to be connected, and in the process fuses and welds together the two surfaces immediately adjoining. With this definition it is possible to immediately confine the talk to the problem involved in welding steel trusses.

It is, however, well to mention that the problem itself would never have arisen had it not been obvious to engineers that tension members of pin connected structures were uneconomical due to the necessity of neglecting in design calculations the strip of metal the full length of the members which is located between and is of same width as the pins, and had there not been frequent complaints about the noise of riveting steel work. If then there are two important incentives to cause engineers to study the design of buildings for the purpose of applying welding, and both of these incentives are directly or indirectly measurable in dollars then we are certain that the problem will be pursued to a satisfactory conclusion.

Riveting versus Welding for Fabricating Structures

The riveting of large buildings in our cities has been the source of much complaint. Boards of health and health commissioners are frequently besieged with complaints regarding the unbearable noise of the steady hammering of riveters at work. All of us have experienced the annoyance of riveting hammers, so if anything can take its place which will produce satisfactory results, even though the expense be slightly higher, we are justified in making the substitution.

The reduction in the amount of steel required for trusses that are arc welded in comparison with trusses that are riveted is only a problem in mathematics. For example, in two typical trusses for one of our buildings calculation of a riveted truss and a welded truss adopted for construction indicated a saving in weight of between 12 and 15 per cent in favor of the welded trusses. Naturally these calculations indicated that engineers were justified in making a diligent study of the entire problem in order to obtain those economies in steel work

*Paper presented before the Boston Section, A. W. S., December 14, 1927.
†Engineer, General Electric Company, Schnectady.

both for the present and for the future. If no other benefit was to be derived except the reduction in the amount of steel required, this alone would be a sufficient incentive to develop methods of designing trusses which would not only obtain economy in material but which would show economy in construction.

It has been definitely shown, at least to our satisfaction, that the cost of welding trusses is no more than the cost of riveting trusses,

Fig. 1. Tension test specimens, ¼ in. and ⅝ in. fillet welds, 3 in. to 6 in. length in laboratory of R. P. I., Troy, N. Y.

and if such continues to be the case the overall cost of welded trusses will continue to be less than the overall cost of riveted trusses. Trusses are fabricated in the shop where actual and definite costs can be more readily established than in the field and the work can be under closer supervision, but there has been insufficient experience to date to determine the actual cost of field work with respect to riveting versus welding. Experience also has not been sufficient to determine the best form of field connections where welding is to be used, while on the other hand, the long experience we have had in bolting and riveting structures has determined very exactly the best forms of bolted or riveted connections to use. It will, therefore, be necessary for all of us to have considerable patience while this problem is being worked out.

The speaker will not claim that welding is ready to displace riveting on field work, but he does claim that development to date indicates that when the technique of field work on welding has reached the high standard with respect to riveting, that the cost will not only be comparable but may even be less, with the additional satisfaction that the quiet of the neighborhood will not be disturbed by the terrific racket of the riveting hammer. Let us also say, however, that we will not, at least for some time, entirely displace pin type connections for erecting purposes. There are at the present time no types of field connections in sight which offer any easier method of bringing members into proper position than field bolting. It may be that some type of joint not yet foreseen will solve the problem, but for the present we

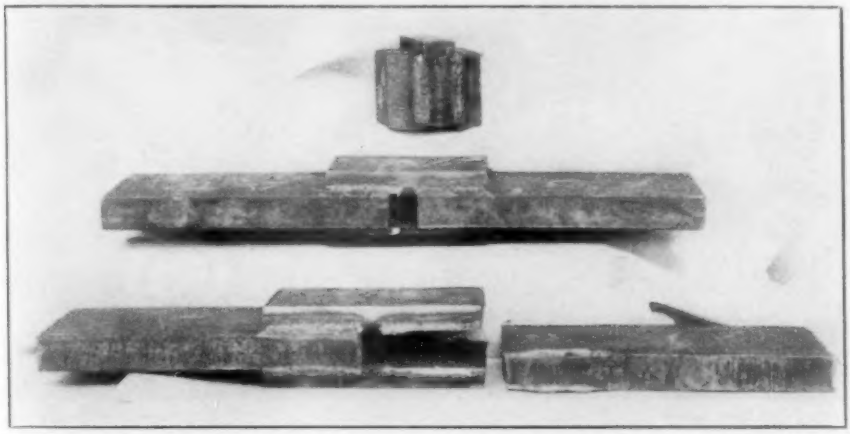


Fig. 2. Tests on welded structural steel, showing compression and tension specimens after failure

prefer to continue the use of field bolts for the temporary connections required when steel is erected.

Lack of Design Data for Welded Structures

When an engineer desires to accomplish a definite purpose he naturally analyses his problem into its simplest terms and then determines the fundamental principles involved. In the design of trusses the methods of calculating stresses have long been determined and there is, therefore, nothing to say at this time on the subject. If, then, the stresses can be readily calculated, there is only one problem left and that is to determine the actual unit stresses to be used for the various types of welds. In order to obtain data for these units the literature on the subject was carefully examined and it was found almost invariably that the specimen itself either distorted badly or broke before the welded joint had reached its maximum capacity. Obviously, that type of test specimen was wrong. It then became necessary to design a test specimen which would fully develop the welded joint to its ultimate capacity without the specimen itself being stressed beyond its elastic limit. In other words, the welded joint must be broken

before the specimen became distorted. In this way the unit stress would be determined for the welded joint and would not be affected by an entirely different problem, that is the unit stress in the member. We are all accustomed to testing steel members independently of riveted joints, but for some unknown reason when welded joints were tested the specimens were not designed to actually test the joint but more to prove that sufficient welding could be applied to complete-

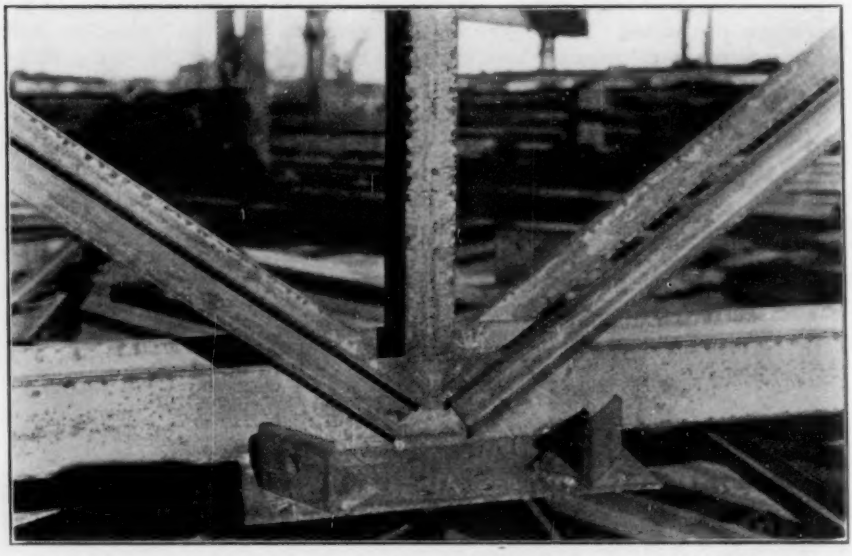


Fig. 3. Showing connections of welded members to form truss. Note elimination of gusset plates

ly distort or cause the member to fail. Of course this latter type of test was of no value in furnishing data for the design of welded joints. It was merely spectacular without producing unit stresses.

Securing Unit Stresses for Welded Joints

From the information given above you will note that specimens for welding tests must be most carefully designed, and a group of twenty-four specimens were so designed for welds of 3-in., 4-in., 5-in. and 6-in. lengths. These specimens were in groups of three, each group designed for testing in tension and compression. In all cases, however, the welds were designed to fail in shear on a plane perpendicular to the long side of the triangular cross section of the weld, as indicated in Fig. 1. This section of the weld, being its weakest plane, is in pure shear if no secondary stresses occur at the joint due to deflection or distortion of the specimens. Of the 96 welds in this series of tests 93 broke along the shear plane and three broke along the contact plane, the shear plane being defined as the plane across the triangular cross section of the weld as mentioned before; and the contact plane being defined as the plane where the welding material is in contact with either member to be joined together. In each of

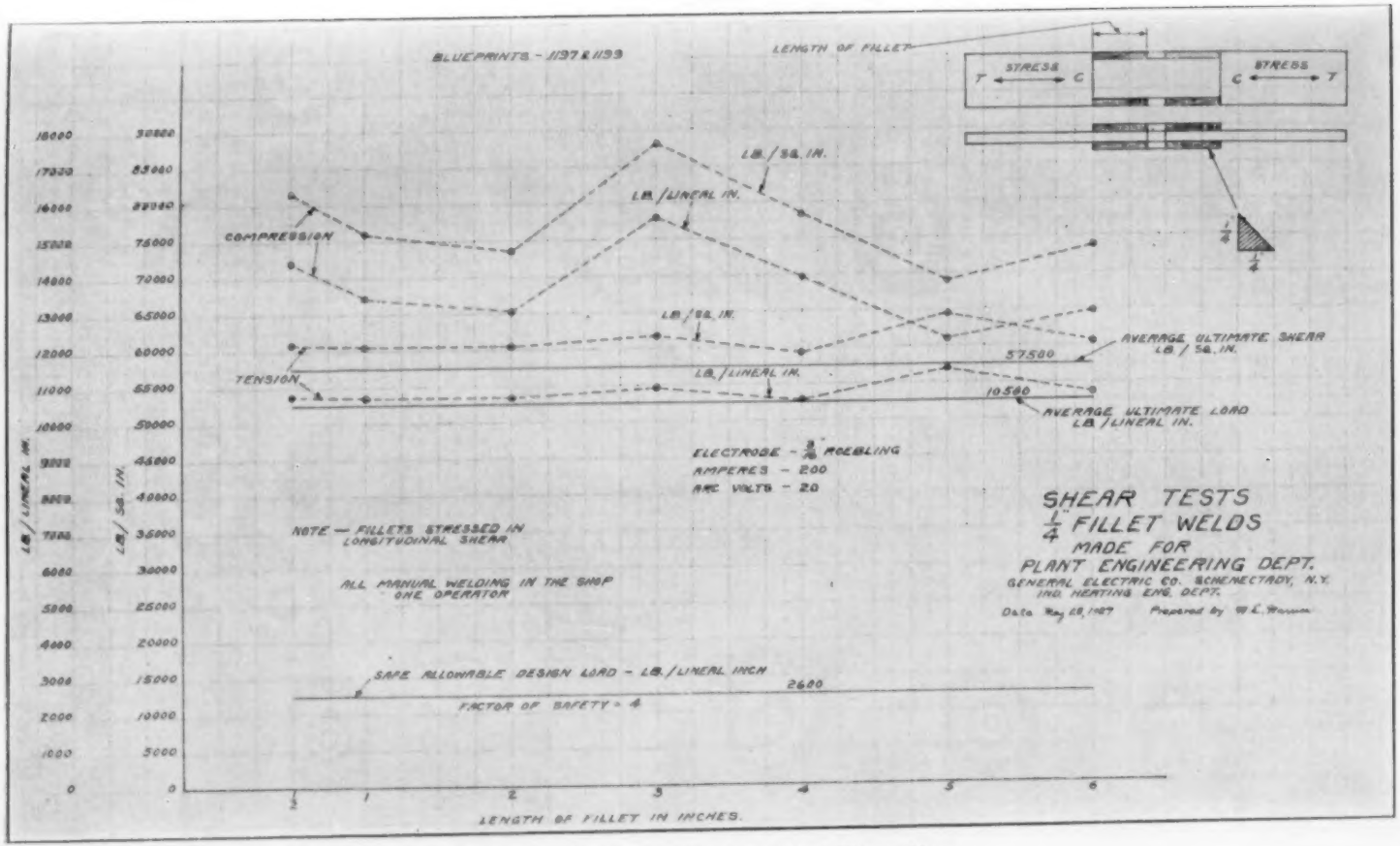


Fig. 4. Results of shear tests on ¼ in. fillet welds

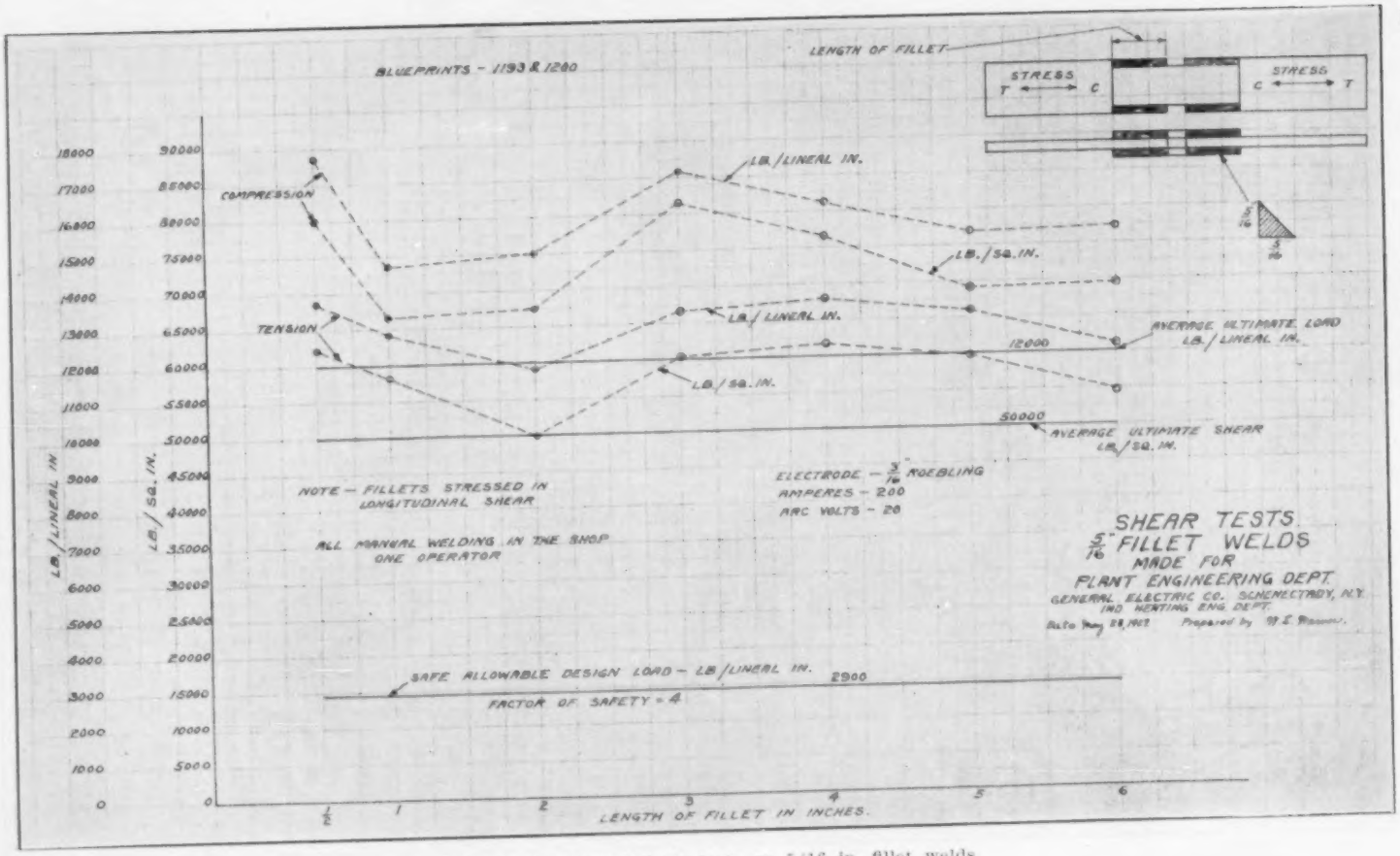

BLUEPRINTS - 1193 & 1200
LENGTH OF FILLET
STRESS T ↔ C
STRESS C ↔ T
5/16
5/16
LB./LINEAL IN.
LB./SQ.IN.
COMPRESSION
TENSION
LB./LINEAL IN.
LB./SQ.IN.
AVERAGE ULTIMATE LOAD LB./LINEAL IN.
12000
50000
AVERAGE ULTIMATE SHEAR LB./SQ.IN.
NOTE - FILLETS STRESSED IN LONGITUDINAL SHEAR
ALL MANUAL WELDING IN THE SHOP ONE OPERATOR
ELECTRODE - 5/16 ROEBLING
AMPERES - 200
ARC VOLTS - 28
SHEAR TESTS
5/16" FILLET WELDS
MADE FOR
PLANT ENGINEERING DEPT.
GENERAL ELECTRIC CO. SCHENECTADY, N.Y.
IND. HEATING ENG. DEPT.
Date May 28, 1927 Prepared by W. E. Stevens.
SAFE ALLOWABLE DESIGN LOAD - LB./LINEAL IN. 2900
FACTOR OF SAFETY = 4
LB./LINEAL IN
LB./SQ.IN.
18000 17000 16000 15000 14000 13000 12000 11000 10000 9000 8000 7000 6000 5000 4000 3000 2000 1000 0
90000 85000 80000 75000 70000 65000 60000 55000 50000 45000 40000 35000 30000 25000 20000 15000 10000 5000 0
1/2 1 2 3 4 5 6
LENGTH OF FILLET IN INCHES.

Fig. 5. Results of shear tests on 5/16 in. fillet welds

the three cases where the specimens failed at the contact plane, bits of the parent metal were torn out showing that thorough fusion had taken place, and in these three cases the unit stresses developed were directly comparable or equal to those where failure was in shear. In order to indicate the uniformity of these tests diagrams are given in Figs. 4-6 on which is plotted each test. These groups are divided into two parts, the compression group and the tension group. You will note that the compression group gave higher values than the tension group, and this has been explained by the fact that the compression group were short chunky specimens in which bending could not occur due to the stresses in the specimens, while the tension group were of necessity long specimens in which bending would occur even though the stresses were within the elastic limit.

From the tests so made it was determined that welding with a minimum contact distance of 5/16 in. and a maximum contact distance of 3/8 in., the variation being specified to allow for the inaccuracies of workmanship, permitted a unit stress of 3000 lb. per lineal inch. The tests indicated a range of 11,570 lb. to 14,040 lb. per lineal inch, with an average of 13,055 lbs. per lineal inch for welding of 5/16 in. contact distance, with ten of the twelve specimens having a value of 12,300 lbs. or more per lineal inch and the other two 11,570 lb. and 11,930 lb. per lineal inch. You will observe that basing the unit stress on the values obtained from the tension specimens alone, a factor of safety of four or better is obtained in practically all cases. If, on the other hand, the compression specimens are considered, a factor of safety of five or better is apparent in all cases. It is, however, necessary to be conservative in any new type of design, and it was for this purpose of being conservative, together with the thought that we must not handicap a new method by too low unit stresses, that the value of 3000 lb. per lineal inch was adopted.

Design of Welded Truss

You have, then, before you the two essentials of truss design: first, the fact that the stresses can be readily calculated for the various members and joints; and second, the unit stress to be used for the design of the joints. The unit stresses used for the design of the members of the trusses mentioned as examples were, of course, those regularly used in the design of structural steel in accordance with standard American practice.

We will now turn to the development of the design of the truss itself. You will notice in Fig. 3 that gusset plates are entirely eliminated in the welded design, and that this is another element of welded design which results in economy. On the riveted truss the stresses in the members must be cared for at the joints by riveting through gusset plates. In other words, the members are not directly connected together but are connected to another element, the gusset plate, which means that the connections are made more than once for each joint in nearly all trusses. The design of the welded truss, however, shows that the members are directly connected to each other so that a unit of connecting material in the welded design is performing one unit of

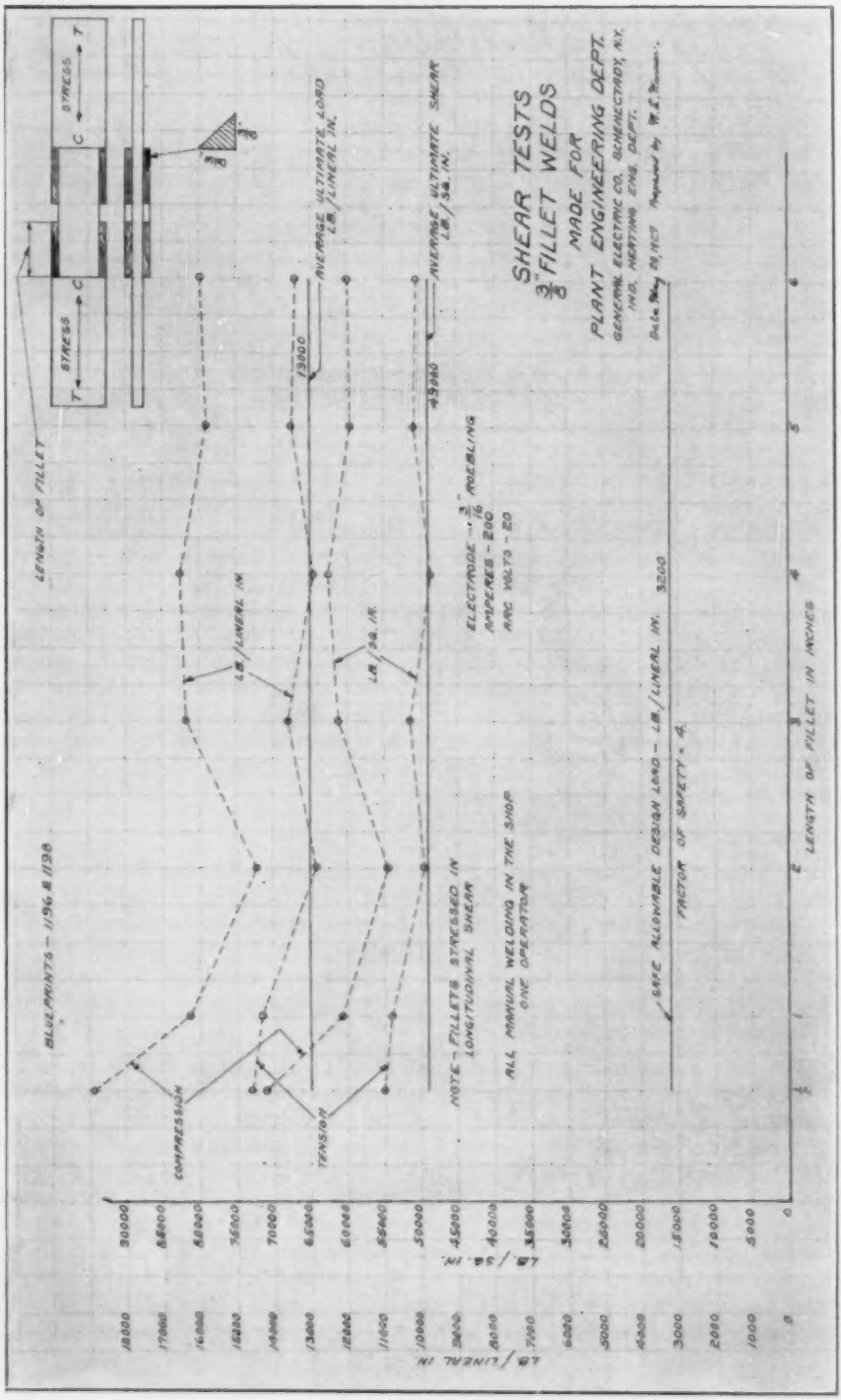

SHEAR TESTS
3/8" FILLET WELDS
MADE FOR
PLANT ENGINEERING DEPT.
GENERAL ELECTRIC CO. SCHENECTADY, N.Y.
INVD. HEATING ENG. DEPT.
Date May 26, 1927 Prepared by W. E. Remmers.
BLUEPRINTS — 1196 & 1198
NOTE - FILLETS STRESSED IN LONGITUDINAL SHEAR
ALL MANUAL WELDING IN THE SHOP ONE OPERATOR
ELECTRODE - 5/16" ROEBLING
AMPERES - 280
ARC VOLTS - 20
AVERAGE ULTIMATE LOAD LB./LINEAL IN. 13000
AVERAGE ULTIMATE SHEAR LB./SQ. IN. 45000
SAFE ALLOWABLE DESIGN LOAD - LB./LINEAL IN. 3200
FACTOR OF SAFETY - 4.
LENGTH OF FILLET
STRESS
COMPRESSION
TENSION
LB./LINEAL IN.
LB./SQ. IN.
LENGTH OF FILLET IN INCHES

Fig. 6. Results of shear tests on ⅜ in. fillet welds

work while more than one unit of connecting material is required in the riveted design in order to perform one unit of work. The comparative sections also indicate that simpler members can be used, resulting in a saving of rolling cost, handling cost, paint and inspection.

The welding is symmetrical with the center line of the truss members. The amount of welding can be directly and easily calculated from the stresses in the members. The problem is just exactly as simple as in riveted construction. The saving in weight by using welded trusses, given at the beginning of this talk, refers to these designs, but your attention is again called to the comparative simplicity of the welded truss with respect to the riveted truss, the omission of gusset plates and the fact that one unit of material in a welded truss performs one unit of work while more than one unit of connecting material is frequently required to perform one unit of work in riveted construction.

For the present it is desirable that welded connections should be designed as simply as possible, that the areas of welding should be concentric with the center or gravity of the members and that all welds should be designed as shear welds. At the present time tests are being developed for other forms of welded connections, but until these tests are repeated enough times to determine definitely the unit values of such connections we have decided it is desirable to continue the simple connections now being used. Riveting and welding should be compared with respect to their relative economy in each particular work and whichever proves the more economical should be used. There is no conflict of merit between the two methods, simply the age old conflict of economy, and whichever proves to be the more economical will survive in its proper sphere. But certainly our experience with welded trusses indicates that this is a field where arc welding is rapidly proving its utility.

Application of Screen Glass to Welding Operations*

By W. G KING†

WHEN we speak of a screen or welding glass we mean a glass that is interposed between the eyes and the flame of a welder's torch, or the arc of an electric welder's electrode. The function of the glass is, primarily, to protect the operator's eyes from the injurious rays emitted by the flame, arc or molten metal. In addition, through its filtering medium assist the user to meet his production factor with the least discomfort to his eyes through a reduction of the so-called annoyance glare and incident light and at the same time to provide clarity of detail.

That such requirements are necessary leads us to wonder what physiological effects result through contact with the injurious invisible rays, the ultra violet and infra red, when the eyes are unprotected. When

*A paper read at the monthly meeting of the New York Section, A. W. S., October, 1927.

†Director, Safety division, American Optical Company, New York.

the eyes are tired, the body is tired all over, a tired worker cannot be efficient or happy, so that the condition of eye strain or uncorrected visual errors slow down production and decrease the quality of the product.

Effect of Ultra Violet and Infra Red Rays

Dr. Nelson A. Black states in The Eye in Industrial Accidents, "That exposure of unprotected eyes to very intense light sources rich in violet rays produce acute and painful inflammation of the outer coating of the eyes; that long-continued or frequent short exposures to ultra violet radiations of moderate intensity may result in severe inflammation by its cumulative action." Ultra violet radiation percentagely in excess of that present in daylight as well as infra red radiation from high temperature molten surfaces are to be avoided for hygienic reasons through the use of special protective glass.

From another authority in the medical profession we are told that the infra red rays dry out and burn the eyes and the skin, producing reddening or irritated eyelids, watering of the eyes and headache and frequently these disturbances are of such intensity as to prevent sleep.

The welder on the job recognizes this sensation of burning which is described by him as being like hot sand in the eyes. Those of us having experience in welding operations are familiar with these complaints of workmen, but in recognizing this condition we sometimes fail to control the conditions through a safety device in the form of efficient welding glass. Undoubtedly some, if not all, of us can look back a few years when we considered an ideal welding glass could be made from a series of several pieces of colored glass, usually red, green and blue mounted in layers. Such glass was obtained at the nearest paint or glazier's shop, or perhaps we liked best the color combination of red and blue. Little did we realize that we were offering little or no protection from the invisible injurious infra red rays.

Protective Glasses

All glass, with the exception of quartz, under most practical conditions, affords protection from the ultra violet. This, however, cannot be said of the infra red. It has been found that clear window glass transmits 78.5 per cent of the infra red rays, while an efficient welding glass transmits less than 1 per cent.

It is also interesting to note that it has been determined that there is only approximately 2.5 per cent variation in the transmission of the rays through thick plate glass over that of the ordinary window glass.

It is quite evident from this investigation that the thickness of the screen has little control in arriving at high absorption efficiency, when this thickness is compared with that of welding glass .093 in. thick.

Recently we learned of a transmission test made on welding glass (so called) built up of several pieces having a total thickness of ¾ in., whose percentage of transmission of the infra red rays was 8 per cent. Frequently in screen glass, thickness may control the depth of or density, but it will not necessarily govern its absorption efficiency.

To the casual observer any piece of glass of a dark hue may be a good welding glass if he is looking only toward a reduction of the incident light and its annoyance glare, giving no attention to the vital factors. its absorption efficiencies of the invisible rays. These can be determined only through laboratory tests, for the ultra violet through a spectroscope and the measurement of the infra red through a diathermic ray instrument.

Appreciating the absorption qualities of a welding glass, we can now look toward some of the physical aspects and their relation to the total of a good glass. It must be free from pits, fine holes, creases, stria or opalescence—factors that produce distorted vision. It should be of uniform thickness throughout and should transmit enough of the incident light to permit the operator to observe the details of his work without eye strain.

Proper Density of Glass

It is on this latter point that the establishment of shades or densities has been developed. The personal factor in the selection of welding glass is interesting and should be taken into consideration. The selection of a light or dark shade of glass for the same job is an indication of the variation in the sensitivity of the eyes to the incident light of the same intensity. As previously mentioned, the shade or density in most cases is a control of individual discomfort. It is for this reason that we frequently hear men say a glass is too light or too dark. It has been shown that the eye is most sensitive to light rays of wave lengths approximately 5500 to 5650 Anstroms, producing a color of yellow bearing on the green. Consequently a welding glass giving this shade enables the welder to observe detail and to do his best work. If the color field approaches either the red or the blue, the operator's perception of detail is decreased and the possibility of the transmission of the infra red is increased.

In conjunction with efficient welding glass, an intelligent selection should be made of its mounting or container, goggle, helmet or hand shield. If a toggle, it should be of the so-called eye cup construction, conforming to the contours of the face, inclosing the eye at the top, bottom and sides, ventilated, but eliminating the possibility of light leak. The goggle is worn first as a protection from the injurious invisible rays, and secondly as a protection against molten metal splashes or foreign particles. It should be borne in mind that a goggle that might prove ideal on a scrap pile job in the yard may be wholly inefficient on a job in a firebox of a boiler or inside a tank.

A helmet or hand shield should be designed to afford ample protection to the face, forehead and throat, and made of a material that is a low conductor of heat and not as sometimes found made of sheet metal having the contours of an inverted sugar scoop.

To summarize this paper, let me quote our Dr. Charles Sheard: "Welders and those working near high power arcs need protection against the ultra violet, a reduction in the visible and elimination of the infra red. It is necessary for all persons whose work requires exposure of

the eyes to excessively bright or highly radiating surfaces to wear suitable light absorbing or protection glasses."

A filtering glass which should be used is one which will cut off both ends of the spectrum, the ultra violet and infra red and which transmits in reduced quantity only rays of high visibility, such as the yellow and green radiations giving the maximum visibility with the minimum reception of energy.

Factors Involved in Economical Gas Cutting*

By J. C. ANDERSON†

A LITTLE more than twenty years ago, there was introduced into this country the oxyacetylene welding and cutting process. During this short period of development, the process has grown to enormous proportions. The growth has been very much like the growth of a child—the early years requiring the tender and undivided care of those pioneers who had sufficient vision and foresight to realize what its full development would mean to the industrial world.

In later years it has grown by leaps and bounds, until there are required a great number of plants for the production of oxygen and acetylene, scattered all over the thickly inhabited portions of the United States. In addition, large factories have been established for the manufacture of torches and regulators and other apparatus required for the combustion and application of these gases in the metal working and other industries.

The process has two distinct branches—welding and cutting. To realize how important the latter has become, it is only necessary to note that it is estimated that more than half of the oxygen produced in this country is used in cutting operations.

The oxyacetylene process, generally speaking, offers great opportunities for economical operation and permits manufacturing processes to be performed at considerable savings over old-time methods. Due, however, to the lack of appreciation of the maximum economies that can be attained by the exercise of good judgment in the use of the process, wasteful practices have crept in which are often unrecognized.

Oxy-Acetylene Cutting an Important Process

We have called attention to the importance of the oxyacetylene cutting process from an oxygen consumption standpoint. Let us now consider the factors that enter into the economical application of this process.

Inasmuch as the cutting operation is primarily dependent on oxygen, supplied under more or less pressure, and is a chemical reaction, we will consider oxygen as the first and most important factor.

In the early days oxygen was produced from chemicals, and as the quality of the chemicals, the design of the equipment and the intelligence of the operators varied, the quality of the oxygen varied accord-

*Presented before the Philadelphia Section, A. W. S., Nov. 21.
†Industrial Engineer, Air Reduction Sales Company.

ingly. As the industry progressed and became more important, oxygen was required in greater quantities and of uniform quality. To meet these conditions, the liquefaction process has come to be the established and practically universal method of production.

Rather early in the history of the process the importance of the purity of the stream of oxygen projected through the cut became recognized. Much work has been performed in determining the economy afforded by the use of high purity oxygen. As a matter of fact, the importance of this factor is now so universally recognized and conceded by engineers that, in line with the demands of the industry, oxygen of 99.5 per cent purity can be procured in almost every important industrial center in this country. Considerable data have been published on this subject by trade papers and the technical press. A study of this literature would indicate to anyone interested that the value of purity is so pronounced that simple tests arranged for shop demonstration will clearly show this fact.

Good Equipment Necessary

Next in importance is the matter of equipment or apparatus, as it is usually called. The cutting process subjects the apparatus to severe conditions, and it is, therefore, essential that, if economy is to be secured in its operation, careful consideration must be given to its construction and durability at the time it is purchased.

The entire equipment—torch, regulators and hose—operates at pressures considerably higher than required in welding. The surface of the material to be cut is frequently in a very undesirable condition—imbedded with burned sand—heavily coated with rust and often covered with several heavy coats of paint. There may also be present pockets and corners. All of which prolong the preheating period—deflect the heat back on the torch and operator, or otherwise subject the equipment to undesirable heat conditions.

Through rough handling, such as using the torch as a pry to loosen the cut piece or as a hammer to knock off slag or to push heated sections aside, the equipment is often abused to such an extent that only the most sturdy will pay for itself before being worn out.

With this said it is not out of line to suggest that effective maintenance of equipment is one very important factor in the economical use of the cutting process.

There should be on hand sufficient equipment so that torches, regulators, tips and hose can be withdrawn from service for repairs when necessary without interfering with plant or department operations. An inadequately equipped cutting department cannot operate economically; torches of a type suitable for the work should be provided, and a range of tip sizes and styles should be on hand to meet any cutting condition that may arise.

The regulators should be of a type that are capable of passing large volumes of oxygen at pressures suitable for the heaviest cutting. The

hose should be of the very best quality to withstand the wear and tear to which it is continuously subjected in work of this kind. The value of the oxygen wasted through a leaky hose will, in a very short period, far exceed the cost of replacing with hose of good quality.

Proper Supervision Essential

Next in importance is the factor of supervision:

The oxyacetylene cutting process appears to be so simple, and as a matter of fact is so simple, that it is often penalized for this very reason.

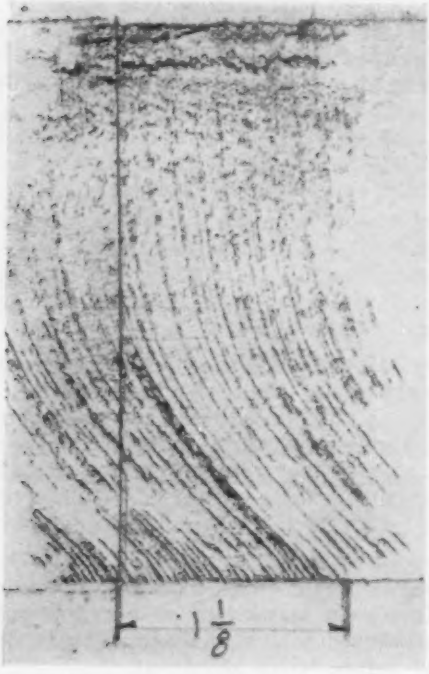


Fig. 1. Cut by operator No. 1 showing 1⅛ in. drag

Fig. 2. Cut by operator No. 2 showing ⅞ in. drag

Its simplicity invites unintelligent supervision or perhaps the need for supervision or direction is not recognized at all. Supervision to be really effective in keeping operating costs down to a satisfactory figure requires a thorough knowledge of the oxyacetylene cutting process and its possibilities. A careful study should be made of what is required from the standpoint of quality of cut, production per hour per man, cost per ton or other unit, space required for efficient operation and other factors that seriously affect the results.

This study should lead to a consideration of equipment requirements and methods of operation and will determine the amount of supervision

or direction that is necessary in order that the work may progress steadily and at a satisfactory cost.

Because it is difficult to control, the human element will trouble the management more than any other one factor. While capable, industrious men can and, of course, always should be secured, there will be a great variation in their ideas as to those details of the process which are really important factors in economical cutting.

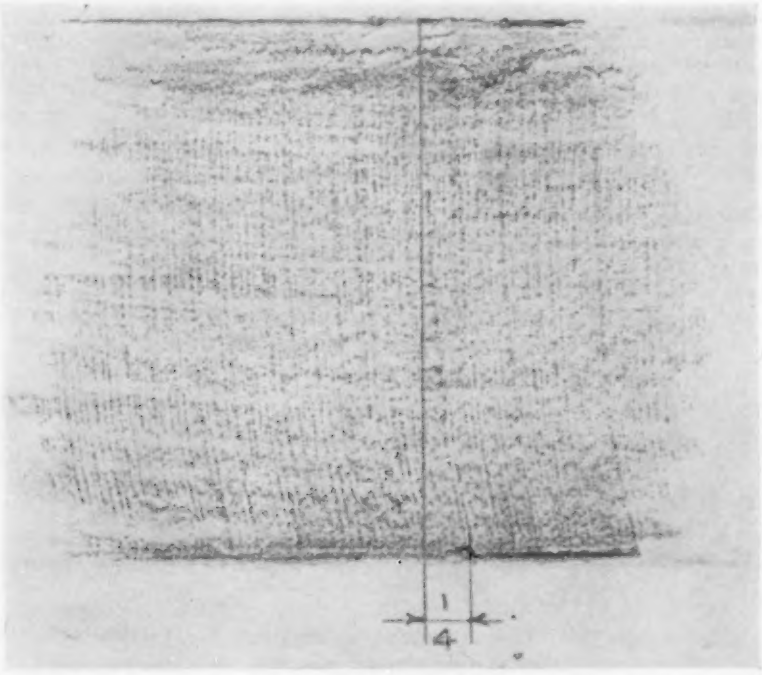


Fig. 3. Cut by operator No. 7 showing ¼ in. drag

The individual operator should be guided in the selection of tip sizes and oxygen and acetylene pressures for the various thicknesses and kinds of material to be cut. He should be urged to move the torch forward as rapidly as it will cut and at the same time produce a satisfactory surface.

Efficient supervision will always take into consideration the ability of the operator when assigning work and will continuously strive to educate the industrious man in order that he may become a more valuable operator.

Tip Sizes and Pressures Should be Specified

Tip sizes and the proper pressures for operation will always be specified for various thicknesses and conditions. The approximate speed can also be established within close limits as a guide for the operator. The

desired quality of surface can be established, and economy in oxygen consumption can be secured if sufficient attention be given these particular features. The selection of tip size and style governs, to a considerable extent, the quality of cut produced, and largely determines the pressure of oxygen and fuel gas used, and the speed at which satisfactory cutting can be accomplished.

Manufacturers' tables of tip sizes can be followed rather closely with profit, but the tendency is more often to use larger sizes than those specified in the belief that by so doing faster cutting can be accomplished. As a matter of fact faster cutting can more often be done with small, suitably sized tips for the reason that the chilling effect is minimized and there is less induction of atmospheric oxygen and nitrogen into the cutting jet to dilute and contaminate the stream of oxygen that will do the cutting at satisfactory speed, and with suitable quality of surface produced will be admitted by everyone.

The style of tip should also be given consideration, and in general it is safe to assume that one with multiple heating flames of small size is suitable for most cutting, except when the material is covered with a heavy refractory covering of rust, scale or paint, in which case larger preheating flames are desirable. The cutting tips receive severe abuse, and too much care cannot be exercised in maintaining their original perfect form and condition.

Tip sizes, pressures, speeds of cutting and quality of cut are so closely related and have such an important bearing on economy that we will consider them in greater detail. The establishment of a correct schedule of oxygen and gas pressures for the cutting of various thicknesses and grades of material is just as important as the insistance on the use of suitable tips. In fact, the specifications for tip sizes and oxygen pressures are so closely related that it is impossible to think of one without considering the other.

We have said that the tip with the smallest cutting oxygen stream orifice which conditions permit should be used, and consequently, in the interest of economy, we must also say that the lowest reasonable pressure of oxygen should be employed which will give satisfactory performance at economical speeds. High oxygen pressures are usually wasteful of oxygen unless the operator, by reason of extensive experience, can operate at a high enough speed to utilize the oxygen economically.

Speed of Cutting Important for Economical Operation

This brings us to the consideration of speed of cutting and its influence on economical operation. There can be no argument as to the influence of speed of cutting upon the cost of operation when it is recognized that with a given orifice and a constant pressure oxygen flows at a constant rate. It is, therefore, important that every effort be made to force the torch to cut at the greatest possible speed commensurate with the quality desired.

Frequently we find that speed is thought to be the most important consideration for the attainment of economical cutting, but we need

only stop for a minute and compare the cost of the oxygen which will pass through a tip of given size in an hour with the hourly labor cost to see that the oxygen cost is a far more important factor. Farther on in this paper we will consider a table which will very clearly illustrate all the points we are specifying as factors in economical cutting, and it may be of interest to note that the average ratio of oxygen cost to labor cost was 3.49 to 1, not considering overhead. It behooves us, therefore, to conserve oxygen, but to the extent only that it does not penalize the operation.

We must remember that in oxygen we are dealing with an invisible power, and while we can see the sparks fly when this power is released in a cutting operation there can be a considerable portion of the oxygen wasted either through ignorance or willfulness by the combination of large tips, high pressure and insufficient speed. Let us try to remember that unless all the oxygen is brought into contact with the steel that is possible through the combined influence of stream size, pressure and speed, we are not using the oxygen cutting process efficiently.

Near the beginning of this paper it was stated that laboratory tests were not required to determine the value of high purity oxygen in cutting, and it is equally true, and fortunately so, that laboratory tests are not required to determine when and how economical results are obtained in shop operations. Anyone who has analyzed to his own satisfaction the phenomenon of oxygen cutting has determined that the most economical cutting is usually done where the drag lines are rather fine but regular at no point parallel to the axis of the jet, yet nearly perpendicular to the surface at the top but curving away rather abruptly in a direction opposite to the direction of travel after one-half of the thickness of the plate has been cut, leaving both top and bottom edges of the kerf clean and fairly sharp. As a rule, the greater the drag under these conditions the more efficiently has the oxygen been used. These conditions of drag line are applicable only for straight line work. For circular or irregular cutting the cutting lines must approach the vertical more closely to avoid under-cutting. If, however, the dimension tolerances are not too close, the same economical operation is possible.

Comparing Operators

It has become standard practice in computing cutting costs, in rating operators or in otherwise establishing values, to compare time, oxygen, fuel gas and labor cost in relation to square inches cut considering one cut surface only.

To illustrate the importance of these various factors viewed from different angles, a table is presented herewith giving the results obtained by seven different cutting operators working on the same grade and thickness of material. In this case the torches were all operated mechanically and, therefore, the question of personal skill does not enter. This table will serve, therefore, to point out that greater differences may be expected in hand cutting under similar circumstances when differences such as shown can exist in mechanical operation when only the tip size, oxygen pressure and speed are under the operator's control and no exertion is necessary other than watchfulness on the part of the operator.

Operator No.	Thickness	Speed	Tip	Pressure	Sq. In. Cut per Cu. Ft.	Drag	Ratio Oxygen to Labor Cost
1	2¾	9.45	25–4	30	7.45	1⅛"	3.50
2	2¾	8.04	24–3	40	8.59	⅞"	2.55
3	2¾	8.	24–3	55	6.56	⅜"	3.36
4	2¾	7.93	24–3	70	5.82	⅜"	3.73
5	2¾	8.	25–4	30	7.02	⅝"	3.13
6	2¾	8.1	25–4	40	6.0	⅜"	3.80
7	2¾	8.74	25–4	50	5.52	¼"	4.38

Here we see the result of permitting operators to put into practice their individual ideas as to tip size, speed and oxygen pressures. Each operator worked on the same grade and thinckness of material.

Operator No. 1 believed in a large tip and low oxygen pressure and just as much speed as would permit uninterrupted cutting. He secured by this reasoning very good economy, but his pressure was too low for the size of tip, and he consequently did not secure the maximum speed and fell a little short of the economical cutting mark established by operator No. 2.

Operator No. 2—In proof of what we have just said, let us look at the work of operator No. 2. We find that he chose a No. 3 tip, which is 39.4 per cent smaller in area than a No. 4 tip, but used oxygen at 10 lb. per sq. in. more pressure than the larger tip. Under these conditions he cut at 15 per cent less speed but at 15 per cent more economy in oxygen. The fact that operator No. 2 cut 8.59 sq. in. per foot of oxygen and therefore did more economical cutting is further verified by the fact that in this instance his ratio of oxygen to labor cost was 2.55 to 1 as compared with operator No. 1 at 3.50 to 1. In other words, operator No. 2 selected a combination of tip size, oxygen pressure and speed that produced at an economical rate.

Operator No. 5 chose the same tip size and pressure as operator No. 1, but did not work up to the capacity of that combination in speed with the result that his operations were less profitable.

Now let us see what it means to go to the other extreme.

Operator No. 4—This man favored small tips and high pressure, and with a No. 3 tip, the same as No. 2 operator, he increased his oxygen pressure to 70 lb. and his speed decreased slightly. The result is extremely poor economy in comparison.

Operator No. 7, who believed in large tips, also believed in a considerably higher pressure than operator No. 1 and a slightly higher speed than the other operators except No. 1, but not in any sense the maximum speed for that tip size and pressure. The result is that his work is even less profitable than that of operator No. 4.

Let us consider the work of all of these men from other angles. We have stated that simple tests could be conducted in the shop to determine the economy of the process, etc. In addition, this chart we are discussing illustrates how the value of the men based on individual ideas and judgment can be determined. It also shows how a standard practice can be established for a particular grade of work by specifying tip sizes, styles

and pressures. It shows, furthermore, the influence of speed on economical torch operation.

Appearance of Surface of Cut Important

The reduction of work done to the basis of square inches cut per cubic foot of oxygen emphasizes the value of utilizing all the cutting power that exists in every foot of oxygen. Ocular proof of cutting efficiency is exhibited in the appearance of the surface of every cut. This was referred to previously in this paper, but we will consider it now with reference to the results as shown in the table under discussion.

The table shows that the drag noticed in the case of Operator No. 1 was 1⅛ in., and ordinarily this would be considered as indicative of extremely economical cutting. We must, however, always take into consideration tip size and pressure in an analysis of this kind. The high speed, large tip size and low oxygen pressure would indicate that the pronounced drag was the result of dilution or contamination of the oxygen stream, to the point where cutting practically ceased. The drag in the case of operator No. 2 using a small tip was indicative of economical cutting, the lines being fine and regular, the top edge was sharp and the face perpendicular, denoting a narrow kerf with clear sharp cutting, affording only a slight opportunity for atmospheric dilution. It is interesting to note that this operator was by far the most valuable cutter from the standpoint of cost ratio.

In an analysis of cutting results we must bear in mind the fact that as the cutting lines more nearly approach the vertical, the cutting operation becomes more costly, for the reason that much unconsumed oxygen is passing out of the cut. This is very emphatically borne out by the figures shown in the table under consideration. The cost ratio figures speak for themselves and stand as a very convincing argument for intelligent supervision covering all details of cutting operations. Fortunately wasteful operating conditions either do not exist or they do not long continue when the oxygen or apparatus manufacturers' cooperation in applying or supervising the process is in effect.

The lowest possible operating cost cannot be approached unless shop conditions are arranged so the men can make the best possible use of their time and keep the torches cutting practically continuously during the total working hours. The realization of this will mean that——

The work will be planned and laid out, and instruction given in the requirements of the job so that each operator can proceed with his work with a thorough understanding of what is expected of him in the matter of production and quality. Segregation of the work should be undertaken so each operator can proceed from job to job without frequent changes in tip sizes. This plan may possibly involve more handling of material than is customary, but a close study of the problem and a trial of this plan will soon indicate that handling material is less costly than the unnecessary use of oxygen.

While it is true that we have had under consideration in this paper the cutting performed on steel plates, the statements made are just as applicable to cutting operations on steel castings or forgings, keeping in

mind that shop practice or methods of production for the latter commodities necessitate the consideration of other factors such as riser design, etc. It will suffice to say that with these important factors which affect cutting results recognized and put into practice and conscientiously followed, there will result an economical use of the oxyacetylene process. Furthermore, the attention on the part of the shop management to these details and the experience gained will indicate just how shop practices in the preparation, handling and treatment of material will have to be modified to permit the realizations of the maximum economy in torch operation.

Automatic Welding of Structural Steel

GEO. A. CALDWELL†

IN an experience with arc welding as applied to structural steel, extending over a period of eight years, the thought had occurred to me at various times that the automatic machine might be used with economy in many cases in this class of work.

Until the Melrose Park Plant of the Mississippi Valley Structural Steel Company at Chicago, came up for consideration, no good opportunity to try out the new idea presented itself; but here with all factors, including design and method of fabrication, under the control of our company, was such an opportunity.

In this situation a machine was constructed under my direction to convey the material to the electrodes and control the welding, and it was used exclusively in fabricating two buildings of that plant. These buildings were the warehouse, to be used for housing stock material, and the painting and loading shed. Being similar in construction, a description of the warehouse and the steps taken in its fabrication will illustrate the process for both buildings.

The Building

The warehouse is a building 340 ft. long by 135 ft. wide, covered and sided with corrugated metal. The main bay has an overhead crane of 20 tons capacity on rails 80 ft. center to center and 25 ft. high. On either side is a lean-to shed 26 ft. wide. The panels are 27 ft. and 8 in. long. All field connections were bolted, except the webs of the crane runway girders were welded to the webs of the columns, and the lower chords of the trusses were spliced at the center by welding on the ground preceding erection.

The trusses are of curved top chord design—the chords being two angles back to back and welded together intermittently forming a tee. The intermittent welding on these chords was the only machine work on the trusses, all other connections being welded by hand.

The Columns

Each main column, excepting details, is made up of five pieces: A web plate, an upper extension to the web plate, a channel outer flange,

†Vice-president, Mississippi Valley Structural Co. and Consulting Engineer.

an I-beam inner flange, and a plate extension to the inner flange, at the upper end.

The I-beam flange extends from the base plate to the cap plate on which the crane runway girders rest. The main web plate extends from the base plate to the top of the crane runway girders. The channel flange extends from the base plate to the cap plate on which the roof truss rests. The upper extension to the web plate is welded to the top of the main web plate and extends to the top of the channel flange. The inner flange of the top extension is a plate, slotted at its lower end to straddle the main web plate, and extends from the cap plate under the girders to the cap plate under the trusses, to both of which it is welded.

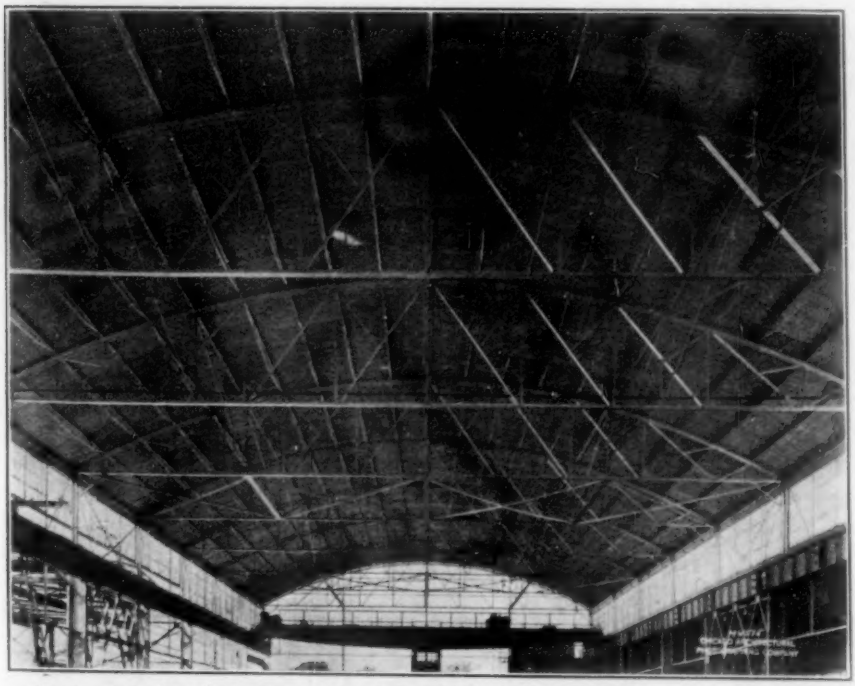
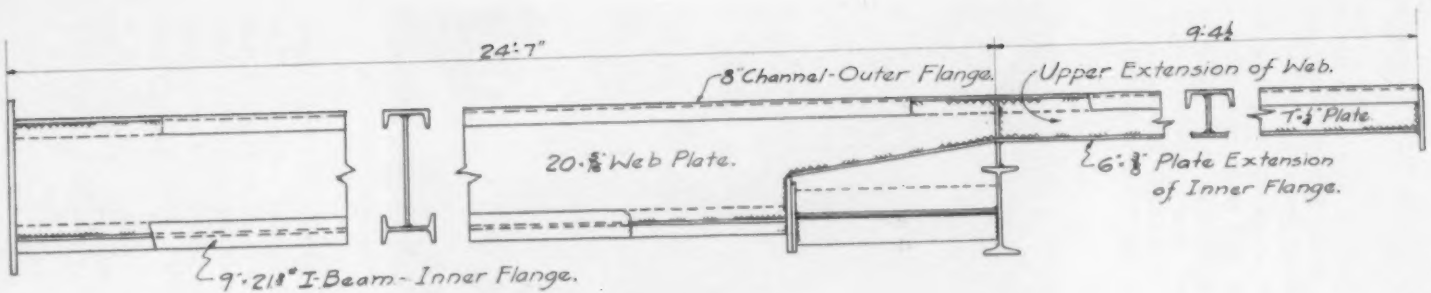


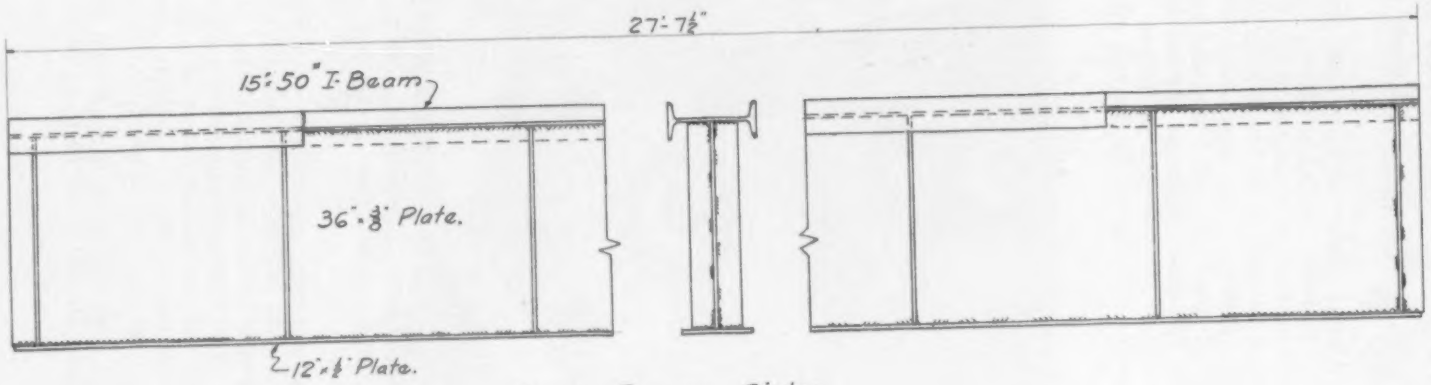
Fig. 1. Interior of warehouse showing welded roof trusses, crane runway girders, and upper part of columns

The preliminary operations on these parts before welding were: The main webs and extension webs were sheared square to length. The inner flanges of the upper extension above girders were sheared and slotted. The I-beam flanges were cut and milled to length. The channels were cut and milled and punched on spacer for field connections. When these operations on the parts were completed, they were laid in convenient places near the welder.

A brief description of the welding machine and what it does, here seems desirable and is set forth as follows: There is a long table, sup-



Columns For Crane Runway.



Crane Runway Girder.

Fig. 2

porting power driven rolls on which the material to be welded travels forward. These rolls have a variable speed, the highest being about 40 surface feet per minute, and the lowest range being 2 in. per minute. The speed is adjustable and controlled by the operator to suit the

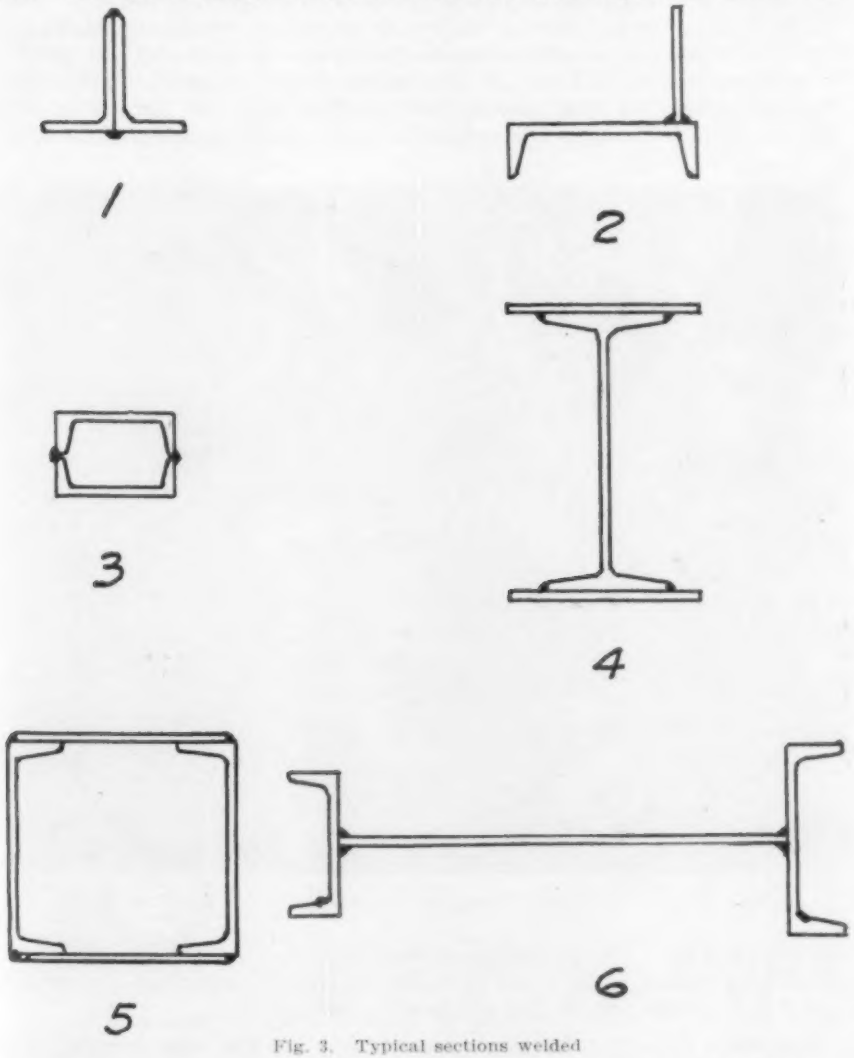


Fig. 3. Typical sections welded

work in hand. Also the rolls are reversible and welding may be done in either direction.

Near the center of the table and above it are guide rolls to hold the members in their proper relation while the welds are being made. Overhead is a hold-down roller for the purpose of applying pressure to insure close contact between the pieces being welded. All these

rolls are adjustable, admitting large variety and sizes within the range of the machine.

On either side, above the center of the roller table, is mounted an automatic welding head and each is wired to its control panel. These heads are so mounted that they are adjustable vertically, laterally and longitudinally, to accommodate the range of sizes and the variety of welding desired. They are also wired in step with the table driving mechanism, so that control is simplified; e.g., the closing of one electric switch changes the operation from continuous welds to auto-

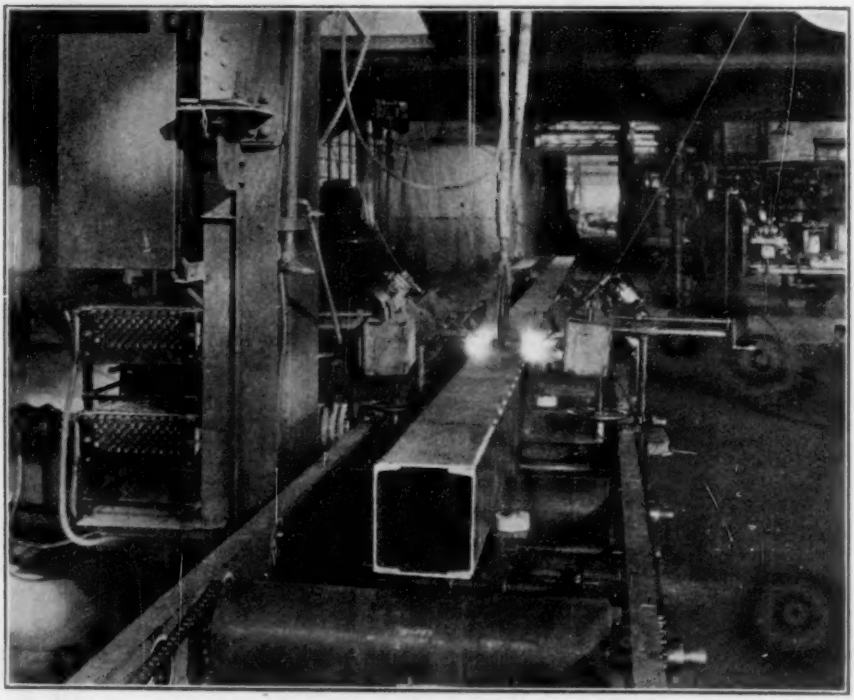


Fig. 4. View of machine welding box column thirty-seven feet in length

matic stitching. (By stitching, as herein used, is meant any series of short intermittent welds used to make completed connection, the welds being of uniform length and uniform in spacing.)

Automatic stitching comprehends cutting off the arc, speeding up the travel of the work to the next weld, slowing down of the travel to welding speed, striking the arc, making the stitch-weld and repeat so long as the switch controlling it is closed. Open that switch and continuous weld again follows.

A wide range of automatic spacing is provided, the shortest being 3⅜ in. and the longest 27 in. between welds. Also the length of the stitches can be made anything desired.

The material for these columns having been assembled at the machine, the welding heads were adjusted to the proper angle and position to lay the fillets where wanted. As the major part of these seams was to be stitching, of 9-in. spaces on one side of the web, alternated with like spaces on the other side, the electrodes were placed 4½ in. apart longitudinally. The speed was adjusted to move the material along 7¾ in. per minute while welds were being made, and a traveling speed between welds at the rate of 40 ft. Using 5/32-in. electrodes and 200 amp. of current, the columns were then put through in the following order:

Welding the Columns

The first operation was the welding of the small webs to the inner flanges for the upper extension, forming a tee section, and as this was done these pieces were laid aside.

Second—The I-beam flanges were welded to the main webs for all columns and these pieces were laid aside.

Third—The channel flanges were welded to the preceding pieces in the following manner, which is typical of all our machine welding, and is here described in detail for one column.

The channel is placed flat on the rolls of the table with the flanges turned up, and that end which is at the bottom end of the finished column, first presented to the welder. A section of the main web, together with its I-beam flange, is now placed on the edge, in its proper position on the center of the web of the channel, the I-beam projecting upward. The base ends of these pieces are made flush, and the whole is advanced through the guide rolls to the first electrode. The hold-down roller is now adjusted to put pressure on the pieces, the channel at this point resting on the center roll of the table, and this roll being a little higher than all the others.

The operator now closes two switches, one controlling travel and the other controlling the first electrode. This electrode strikes its arc and continues welding as the material advances. When it reaches the second electrode the operator closes its switch and it begins welding. There are now two seams being welded on opposite sides of the web plate, one 4½ in. in advance of the other. This continues until the space requiring continuous weld is covered. Then the operator closes a fourth switch. Stitching now begins and continues until a point is reached where continuous weld is again called for, such as a point where a truss is to be connected to the channel, and a stronger seam is desired to take the load coming on at that point. In the work being described, near the end of the main web plate was such a place. Here the operator opens switch No. 4 and continuous welds follow until the first electrode reaches the end of the plate.

The welding is now halted and one of the tee sections resulting from the first welding operations on these columns is placed in position, its top end being made flush with the top end of the channel flange and welding is continued to the end. This completes the machine work on

the column which is now taken to an adjacent space and the details welded on by hand.

The details include a base plate, a cap plate on top of the column, a bar on inner flange to connect a brace from the truss, some stiffeners and a cap plate on top of the I-beam flange to serve as a seat for the crane runway girders. This cap plate was let into the web of the column by notching the latter with a torch, and, with the plate in place, the notch was closed by welding all around. The two forks of the inner flange of the upper extension were bent over and welded to this lower cap plate and stitched to the main web plate. Also the main

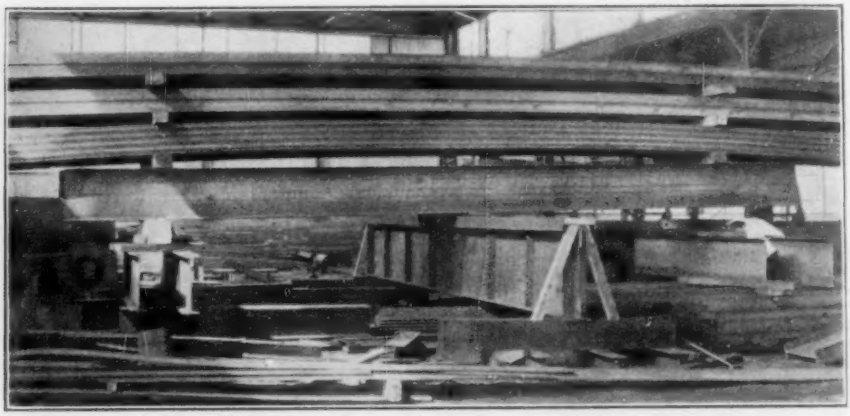


Fig. 5. First girder welded on automatic machine, under proof test load of 59 tons

web plate and its extension were joined together by welding at this time.

All field connection holes, except those located in the details, were placed in the webs of the channels, thus greatly reducing the amount of material handled at the punches and simplifying the punching operation.

Crane Runway Girders

The crane runway girders were each made up of three pieces, except stiffeners. A 15-in., 50-lb. I-beam for top flange, a 12 x ½-in. plate for bottom flange, and a 36-in. x ⅜-in. plate for web. The webs and top flanges were 27 ft. 7½ in. long. The bottom flanges were cut ¼ in. shorter at either end, to clear fillet on column cap plate, made in welding the latter into the notch of the column web plate.

The punching required in this material was four holes in either end of the lower flange plate to connect the girder to its seat plate on the column, and holes along the top flange to connect the rail clamps. Also there were holes in some of the stiffener bars to attach the collector wires carrying current to the crane.

As only two double seams were needed, the girders were a less complicated job for the machine than the columns. The lower flanges were

first welded to the webs for all girders, and this was followed by welding on of the top flanges.

The welding speed on the girders was reduced to 5¾ in. per minute, the travel speed remaining the same as that for the columns. On the lower flange a continuous double seam 30 in. long was required at either end of the girder. Over the intervening space stitches 2½ in. in length, spaced 6¾ in. apart, were used on one side of the web plate, alternating with like spaces and stitches on the opposite side. On the top flange there was similar arrangement and spacing to that on the bottom, except the continuous welds at either end were 36 in. in length, and the stitch welds were 3⅜ in. long, the latter being equivalent to one continuous weld.

For this spacing, the electrodes were adjusted 3⅜ in. apart longitudinally, and it will be noted that where a continuous double seam is made with electrodes so spaced, one of the seams will be longer than the other. As it complements the arrangement of the stitches no attention is given to this fact, except to make the shorter of the continuous welds in the double seam the full length called for.

When stitches precede or follow continuous welds, the latter usually overrun in length a small amount, sometimes as much as the length of the stitch which is being used in that seam. This fact also is ignored and the extra length of continuous weld thrown in for good measure, as less time is consumed in making it than would be required to adjust the spacing to the exact spot.

The end stiffeners, two 5 x ½-in. bars, and the intermediate stiffeners 4 x ⅜ bars were milled to a drive fit and welded in by hand, on an adjacent floor, thus completing the girders.

Some Test Results

The first girder welded was an exception to the above in that the flanges on it were welded at the rate of 7¾ in. per minute. Also coupons were tacked on at the beginning and end of each seam of this girder, and welded by the machine as they passed through. The coupons were knocked off after the girder was completed and were pulled in a testing machine, showing values from 7600 to 9400 lb. per lineal inch. This girder was placed under a test load of 58 tons distributed over 6 ft. at the center, and showed no sign of failure in any of the welds. The girder deflected under that load 5/16 of an inch at the center, and strain checks appeared in the mill scale on the plate around some of the stiffener welds. The stress in lower flange was 26,000 lb. per square inch.

Other members in the building, welded on the machine, were a large number of struts made of a channel with a bar welded on the back similar to Fig. 2 of typical sections shown herewith.

No warpage or distortion was noticeable in any of the work except, where the lower flanges of the girders were welded with two continuous seams at the ends, the plates were slightly troughed. This trough-

ing of flanges also occurred to a less degree at the ends of the columns where two continuous seams were made.

Flanges on both girders and columns were held to a tight bearing on the web plates throughout, and it was noted that this was essential to the making of good welds with the machine.

Two men operate the machine, one acting as a helper in placing the material and observing the second arc as the welding proceeds.

From the rate of travel and the welding speed, the time consumed in making a welded seam can be figured, and this time will closely correspond to the observed time on a number of these seams. Costs also can be figured and it will be apparent that there is some saving over riveted work. This also checks with our cost sheets on this job. Altogether, it was a very satisfactory adventure, and we have been widely complimented on the appearance of the work.

New High Strength Joint*

By H. E. ROCKEFELLER†

FOR some time engineers of our company and the United States Cast Iron Pipe Company have been conducting a joint investigation on the laying of cast iron pipe lines with bronze-welded joints. As part of this investigation, an experimental line was laid under conditions that permitted careful study of the various factors involved. Certain of the data thus obtained seemed to indicate that the collar type of joint had certain defects. Since a strong leak-proof joint for cast iron pipe is one of the most important problems confronting the gas distribution industry, it seemed desirable to review the entire question of the design of joint for bronze-welding of cast iron pipe.

In the early stages of bronze-welding development, several types of joint design were investigated, namely, the vee, collar and combined vee and collar. Tests made on strips cut from the pipe showed that failure occurred at the cast iron adjacent to the bronze for all cases of collar type design, whereas the simple vee type failed along the bevel. Since the collar design took advantage of the well-known high shear strength of bronze adhering to cast iron, and furthermore, since all of the breaks with the collar type occurred in the pipe itself, it was decided that the collar was the correct design, and this type has been used almost exclusively in all installations.

Flexure Tests Show Weakness of Collar

Since the early tests were made simply on strips cut from the pipe, and since the present investigations seem to indicate that the collar type joint is not as strong as it was thought to be, it was deemed advisable to make cross bending tests on full-size 12-foot sections. Both plain and jointed pipe were tested. Tests were made in a 100,000-lb. testing machine, using a 14-ft. length of 10-in. I-beam as a base. Rocker sup-

*Presented before New York Section Meeting, Dec. 2, 1927.
†Linde Air Products Co.

ports were mounted on the beam to hold the ends of the pipe sections. Pipe was tested as a simple beam, load being applied through a rocker knife edge at the center of the span, which was 10½ ft. in practically all cases. Jointed samples were prepared by bronze-welding two 6-ft. sections together, using the collar type weld. As shown in Fig. 1, the load was applied directly to the collar so as to produce the maximum bending movement and stress at the joint.

The results of these tests summarized in Table I show that the strength of the bronze collar joint is only about 55 per cent of the strength of the

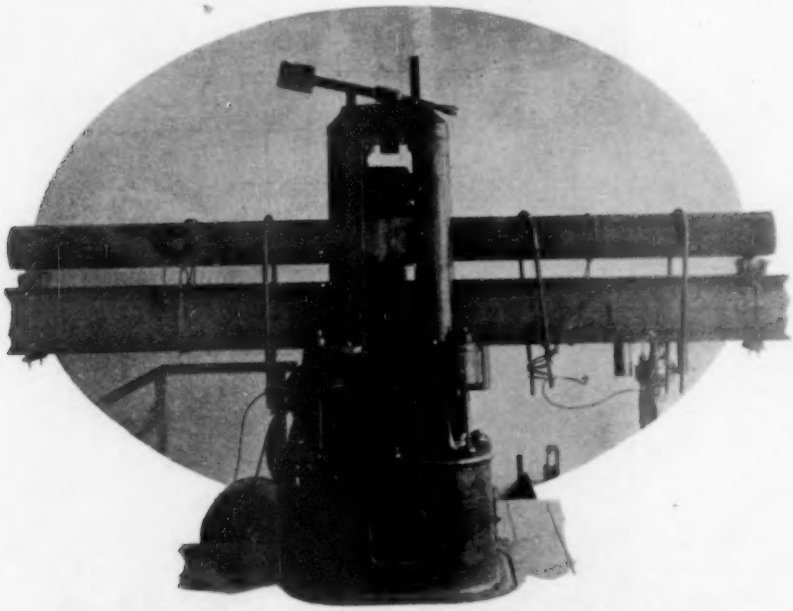


Fig. 1. Cross bending test of collar type bronze weld in cast iron pipe

pipe itself when deLavaud pipe is used. With sand cast pipe, the collar joint is considerably weaker, having only about 42 per cent of the strength of the pipe. In all cases, failure occurred in the cast iron at the edge

TABLE I—FLEXURE TESTS—CAST IRON PIPE

	Modulus of Rupture, Lb. per Sq. In.	Joint Efficiency, Per Cent
6-in. deLavaud cast iron pipe:		
Plain pipe	34,500	100
With collar type bronze weld	19,000	55
With vee type bronze weld	28,750	83
With shear vee bronze weld	32,950	96
6-in. sand cast iron pipe:		
Plain pipe	27,170	100
With collar type bronze weld	11,450	42
With vee type bronze weld	21,500	79
With shear vee bronze weld	27,500	100

of the collar. The collar type weld apparently has a decided weakening effect on the cast iron next to the joint, causing failure at half the strength of the unjointed pipe.

Collar Failure Due to Stress Concentration

Numerous theories have been advanced as to the cause of the weakness of the joint or of the cast iron adjacent to the bronze weld. Careful

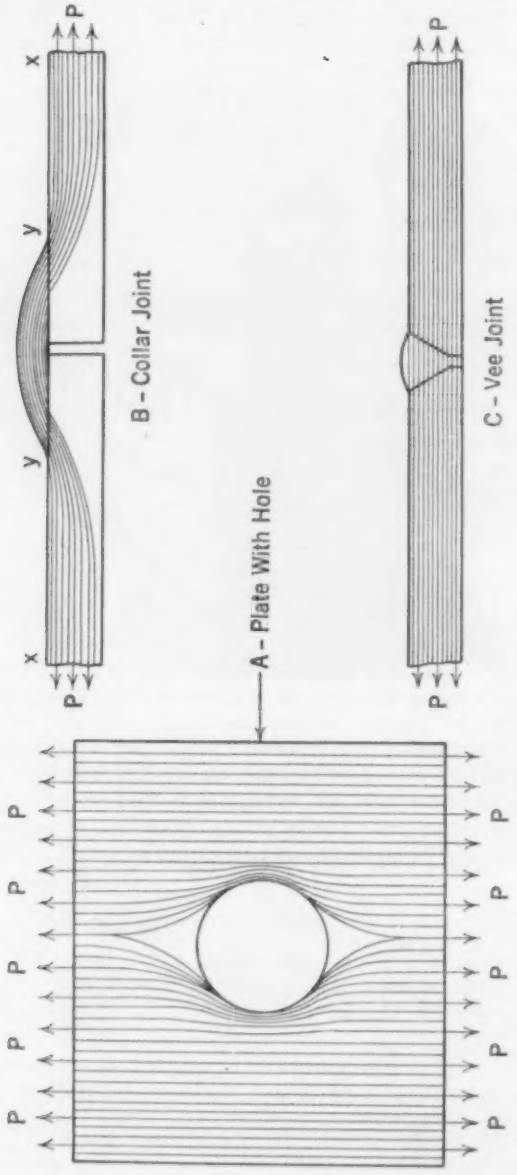


Fig. 2. Graphic representation of stress transfer in collar and vee-type joints

investigations have shown that the bronze-welding operation produces no change in the chemical properties or physical structure of the cast iron adjacent to the bronze weld. If this is the case, then why does failure always take place in the cast iron immediately adjacent to the bronze collar? The answer as determined by the present investigation lies in the mechanical design of the collar joint. There is a concentration of stress in the cast iron next to the bronze collar which causes the failure.

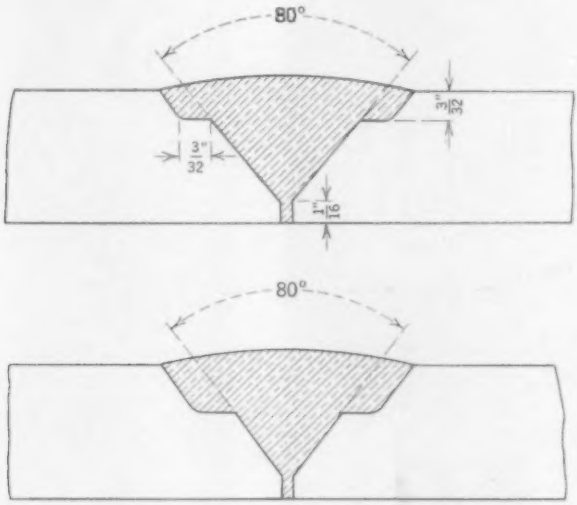


Fig. 3. Shear-vee type joints

This is evident from a study of the stress transfer in this type of joint. It may be shown graphically, as in Fig. 2. For any metal under strain, stress distribution may be represented by lines of stress or flow lines. If load is uniform over the cross-section, these lines will be evenly spaced. If the distribution is upset, stress concentrations will be represented by the bunching and crowding of the stress lines. As an illustration, consider a plate subjected to a uniform load, as in *A* in Fig. 2. Along the sides of the plate the stress lines are uniformly distributed, but at the center where a hole has been cut in the plate, the stress lines must flow around the opening to transfer the stress in that section, and there is a bunching of the stress lines at the edge of the opening, indicating high stress concentration at this point. That such is the case is a well-established engineering fact, and it has been shown by actual experiment that the stress is three times that in the rest of the plate.

When a stress transfer diagram is made for the collar joint, as in *B*, Fig. 2, it is immediately evident that there is a very decided stress concentration in the cast iron next to the joint, as shown at *y*. The stress at this point may be two or three times the stress in the pipe further away from the joint. With the collar type in cast iron, the fibers in the section next to the bronze will be stressed to the point of fracture under a relatively low load, since they may be under a stress concen-

tration of over twice the average in the pipe. It is at this point in stress concentration that failure invariably occurs.

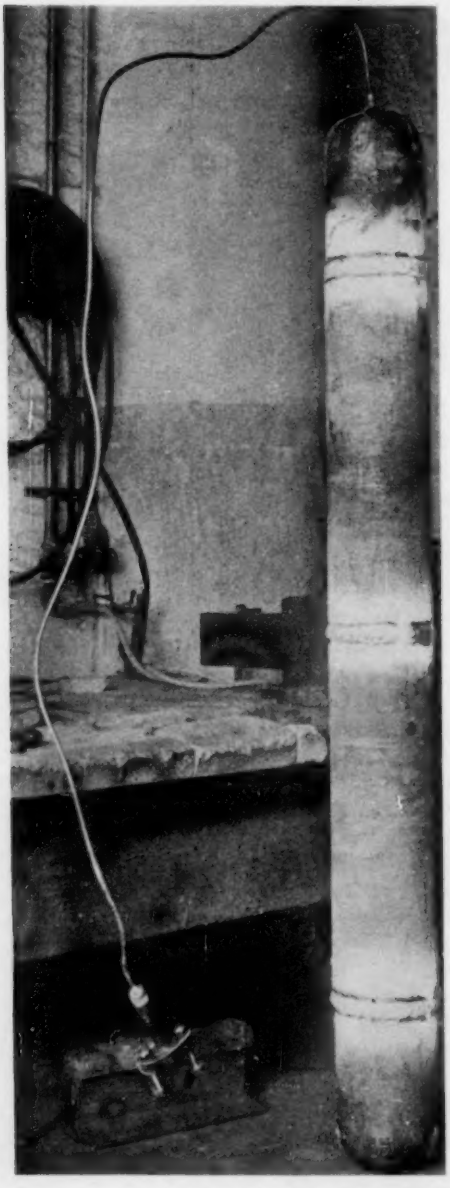


Fig. 4. Hydrostatic test bomb
Made of two 2 ft. lengths of class 150 de-Lavaud pipe joined with the shear-vee bronze-welded joint. The ends were closed with steel bull plugs bronze-welded on

Fig. 5. Bomb after testing. Fracture practically longitudinal although partly spiral. Bronze welds not affected by fracture

Vee Type Joint Gives Better Stress Transfer

To effect uniform transfer of stress from one section to another through a joint, the simple vee type is much more efficient. As shown at *C*, Fig. 2, there is practically a straight line transfer of stress through this type of joint. As mentioned previously, the vee type joint was tried in the early experiments of bronze-welding cast iron pipe, but the tests seemed to indicate that this joint was weaker than the collar type. However, it is now known that failure in these tests was due not to the design of the joint, but to improper preparation of the beveled surfaces of the pipe.

When cast iron pipe is machined, the machined surface is extremely difficult to tin, and there is very poor adhesion of the bronze to the surface, due apparently to the graphite flakes that are exposed. This machined surface is easily decarbonized by annealing to a bright red, after which the tinning operation becomes practically automatic. Since this fact became known it has been standard practice to machine the ends of cast iron pipe and anneal for bronze-welding. Unfortunately, this necessity for annealing was not known by the earlier investigators of the vee-type joint.

Simple Vee Stronger Than Collar

In order to check the theory that the vee-type joint made on properly annealed beveled surfaces, should show a much higher strength than the collar type joint, it was decided to make cross bend tests on full-sized pipe, using the vee-type joint. Results as summarized in Table I show that the reasoning was correct, for the strength has increased to 70 to 83 per cent of that of the plain pipe. It is interesting to note that this simple vee joint, although its strength is not quite equal to the pipe, is more efficient than any known mechanical joint.

A study of the type of failure brought out some very interesting points. Failures occurred in every case along the vee. Generally a fracture in deLavaud pipe showed a layer of cast iron adhering to the bronze at the bottom of the vee or at the inner part of the pipe wall. At the outer part of the wall, fracture followed along the tinned surface of the bevel, leaving a very thin coating of bronze on this part of the pipe.

This type of failure showed that the adhesive strength between bronze and cast iron in tension was not fully equal to the high tensile strength of the deLavaud pipe. Therefore, the simple vee joint was redesigned to introduce a shear area, thus utilizing the known high shear adhesion of bronze and cast iron to assist the tensile adhesion along the bevel. Results of flexure tests are summarized in Table I.

Failure occurred in the cast iron, showing that the full strength is obtained when the vee type joint is reinforced by a small shear area.

Further tests of the shear vee joint were made by preparing hydrostatic bombs. Two 2-ft. lengths of class 150 deLavaud pipe were united with the shear-vee joint. The ends were closed with steel bull plugs to insure uniform stress distribution in the bomb (Fig. 4). Two of these bombs were made and tested to destruction with hydrostatic pressure, one requiring 27,800 lb. per sq. in., the other 24,500 lb. per sq. in. These agree closely with published data on the bursting tests of cast iron pipe.

Both bombs fractured longitudinally in the pipe (Fig. 5), the bronze welds appearing to be unaffected.

Most economical design is obtained by using a 40-deg. bevel with the additional shear area about 3/32 in. from the outside of the pipe wall. For ease in laying and economy in cost this distance seems to be constant for practically all wall thickness of the pipe.

The Shear-Vee Type of Joint

The shear-vee type joint is a modified combined collar and vee joint with the bronze within the limits of the pipe wall. With this joint there is no detrimental stress concentration or eccentricity.

In welding this joint, little or no thickening or reinforcement is required. The bronze has an ultimate strength of 40,000 lb. per sq. in., so with the depth of the weld equal to the thickness of the wall, the deposited bronze is stronger than the pipe.

The shear-vee joint for bronze-welding cast iron pipe has numerous advantages over the collar joint, besides being decidedly stronger. From a welding standpoint, the joint, if properly prepared, is easier to make. With the collar joints, considerable difficulty is experienced by operators not experienced with this construction, in making the collar of correct dimensions and in equally spacing it over the abutting pipe ends. An excess amount of bronze was used with this joint, which, since it constituted the largest individual item of cost, made the joint needlessly expensive. With the shear-vee joint, the dimensions are controlled and guided by the nature of the design. All that is necessary is that the vee is filled. The cost of this joint, which includes machining the pipe ends correctly, is slightly less than that of the collar type. It is, however, more expensive than the low cost vee joint, which is approximately 25 to 50 per cent cheaper than the collar type.

Searing, or annealing, which costs the same as for the collar type, is done at the pipe manufacturer's plant. It should not be attempted with the blowpipe, except where absolutely necessary for special construction in the field, as it may easily be improperly done.

The much higher strength of the vee and shear-vee types of joint has significant importance in considering the success to be obtained with bronze-welded cast iron lines. The field experience with bronze-welded collar construction showed that even with a joint of only 40 to 50 per cent the strength of the pipe, failure occurred in only about 2 per cent of the total joints laid. Ninety-eight per cent of the joints, consequently, were subjected to strains less than 10,000 to 18,000 lb. per sq. in. intensity, as otherwise failure would have resulted. Of the 2 per cent that failed, the stresses probably were just in excess of the strength of the collar joints. It can readily be seen, therefore, that an increase of 100 per cent in the strength as obtained with the shear-vee joint will mean the elimination of the few breaks which did occur. Moreover, in the early laying of bronze-welded lines with the collar joint, no particular care was exercised to minimize either the temperature or bending strains, as it was believed the joint was stronger than the pipe and would withstand any stress. However, bronze welding converts the sections into

a continuous tube of cast iron, and tensile stresses from bending and temperature must be controlled within safe limits. As shown in "Controlling Temperature and Bending Strains in Bronze-Welded Cast Iron Pipe Lines," safety can be assured by exercising a reasonable amount of care in laying and by effectively using expansion joints.

The bronze joint has a lower electrical resistance than any of the common joints used with cast iron pipe; hence, it conducts any stray currents which may be traveling the line without the joint being attacked by electrolytic action, as may occur when a high resistance joint causes the current to leave and reenter the line.

Inspection of joints in service over a period of four years and investigations conducted and reported by the Committee of Corrosion of the American Gas Association and U. S. Bureau of Standards have shown that the rate of corrosion is no greater in or adjacent to the joint than in any other part of the pipe.

With the strains minimized and with a joint that actually approximates the strength of the pipe, success is assured for the leakproof, long-lived installation that bronze-welded cast iron pipe construction offers.

Summary

In conclusion, this investigation and test of bronze-welded joints in full size members has established the following facts:

(1) The bronze-welded collar joint for cast iron pipe is inefficient.

(2) The weakness of the joint and the characteristic failure that occurs in the cast iron next to the bronze collar is not, as has sometimes been contended, due to shrinkage of the bronze collar, structural change, or any detrimental effect on the cast iron from heat or the bronze-welding process. The weakness is in mechanical design and is the result of a very high stress concentration adjacent to the collar.

(3) The bronze-welded vee joint is from 50 per cent to 100 per cent stronger than the collar joint. The strength of the vee joint, although not exactly equal to that of the pipe, approximates it. Searing or annealing the machined bevel is necessary to insure a strong positive union between the bronze and cast iron.

(4) The shear-vee joint, by adding a shear area to the strong vee joint, develops practically the full strength of the pipe.

(5) The vee type joints, in addition to being stronger, require less materials, are more easily and quickly made, and are hence cheaper than the collar joint. They compare favorably in cost with any of the common mechanical joints in use which do not have the absolutely leakproof, non-deteriorating qualities offered by the bronze-welded joint for cast iron pipe.

(6) Under ordinary conditions, the use of these joints, combined with reasonable care and thought in laying and placing expansion joints, guarantees the elimination of failures in a bronze-welded cast iron pipe line.

The Metallurgy of Welding Wire*

By C. A. McCune†

ALL authorities are agreed that a properly made weld involves good base metal, suitable metal to be welded, good welding wire, a trained operator, and good equipment. In these days of automatic electric welding, the personal element of the operator is dispensed with, and by this elimination there is a contradiction of the old fallacy that 85 per cent of the success of satisfactory welding is due to the operator. It is naturally essential, however, in manual welding that the work be performed by a skilled operator.

Satisfactory welding apparatus is readily obtainable today. The majority of welding operators are capable men but unfortunately the base metal which is not always suitable for welding must be taken as received, and the welding wire is a specialty. While my subject deals only with the welding wire, the other points mentioned are involved as fundamentals.

I will attempt to show in the time allotted some of the things we have been studying over a period of years that indicate the important position welding wire occupies in the art.

Some time ago an effort was made to determine what constituted an unsatisfactory welding wire as well as a satisfactory one. About twenty groups of wires were secured from various sources, these wires being submitted with the statement that good welds could not be secured with them. Hundreds of specimens taken from these wires were examined for chemical analysis, physical properties, microstructure, and weldability, the details of which I will not bother you with. The materials involved those used for both gas and electric welding.

In some cases the chemical analysis showed the material to be what could be considered a very good grade of metal and in other cases a quite average grade. The carbon contents for instance range from 0.02 to 0.20. The tensile varied from 40,000 to 100,000 lb. per sq. in. The elongation varied from 2 per cent to 30 for material intended for the same purpose. The microscope revealed structures that were all over the map, from very well annealed to hard drawn, and from clean to very dirty metal. The weldability tests bore out the fact that these metals were unsatisfactory for welding purposes.

Some attempts were made to determine the gas contents of these wires but due to lack of sample we were not very successful in that respect. However the point is that none of the standard methods really showed definitely why the wires were unsatisfactory.

For some years we have been using what has been termed the "flame test" and by this test, (which consists simply of melting down the surface of wire with a small oxy-acetylene flame) we were able to see some of the things that were causing imperfect welds.

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*Presented before meeting, Boston Section, A. W. S., December, 1927.
†Director of Research, American Chain Co.

The results obtained by the flame test in which it was developed that the metal in unsuitable wire boiled with a disturbing action when melted, and that the metal in a satisfactory wire melted quietly and smoothly without any evidence of gases or other inclusions. The results of using unsatisfactory wire were also shown and it was brought out that it was possible to make what appeared to be a satisfactory weld, i. e. from all optical observations there was nothing to indicate on the surface that the weld was other than a satisfactory one. However, when the weld was cut in two the defects that were apparent in the wire were embodied in the weld. Other photomicrographs show the effect of welding heat on electrodes whereby it developed that the heat used in melting down the electrode affected a structure of the electrode itself to the extent of developing seven different structures in a distance of only 3/16 in.

"What is a satisfactory welding wire?" "How can a satisfactory welding wire be specified, and what are the means for checking the wire against specifications?" In answer to the first question, it is evident that a satisfactory weldng wire must be free from excessive impurities such as gases, slag, etc., and for electric welding a special added requirement is that the structure be such that the arc will be properly directed. It is difficult to specify such requirements. The only attempts made now to cover welding wire by specifications are that the usual elements such as carbon, manganese, phosphorus, sulphur and silicon be limited. Experience shows that this is not sufficient. It is necessary to add other requirements but just what these are has not been thoroughly defined. The flame test could be included as it is easily and rapidly made and would give a clear indication of what might be expected in the use of a material.

This so-called flame test can also be produced by an electric welder in which the electrode is frozen to the base metal, holding it there until it reaches the melting point. The same characteristics will be observed by this method as in the flame test.

Within the past year in my contact with those having to do with specifications outside the American Welding Society, I have found some who believe that a better welding wire would be secured by reducing the sulphur content, for instance, from .045 to .03 and that juggling the carbon content around would probably help but we know that neither of these contribute very much, if anything, in the assurance of a satisfactory welding wire.

I have tried in this paper to bring to your mind the need of the careful selection of welding wire and I trust that whatever evidence that I have been able to offer to you today will lend further encouragement to a study of this very important factor in successful welding by others.

Pipe Welding by the Thermit Process*

By R. L. BROWNE†

WHAT is now universally known as the Thermit process was originally perfected by Dr. Hans Goldschmidt of Essen, Germany, for the reduction of pure metals from their Oxides. While there are many Thermits, depending upon the metal oxide used, this paper will be confined to Iron Thermit, which is the variety used for welding purposes, and referred to herein merely by the term "Thermit" for the sake of brevity.

Thermit is a mixture of finely divided Aluminum and Iron Oxide.

The fundamental principle of the Thermit Process is the high chemical affinity of aluminum for oxygen. Stated in simpler terms, it is really aluminum burning with the oxygen of iron oxide sustaining combustion, just as for instance paper or wood would burn in air with the oxygen of the atmosphere sustaining combustion. It is more difficult, of course, to start aluminum burning, requiring as it does a temperature of 2800 deg. Fahr. Once started, however, it continues to burn without further external application of heat. The initial temperature (2800 deg. Fahr.) is obtained by means of a small quantity of so-called ignition powder placed in one spot anywhere on top of the Thermit in the crucible which is in turn ignited with a match.

The aluminum in burning combines with the oxygen of the iron oxide to form aluminum oxide or slag, setting the iron free. The slag being lighter than the iron floats on top. The temperature of this reaction is approximately 5000 deg. Fahr., a temperature which properly controlled can be utilized to advantage in many ways for welding purposes.

Briefly, in joining pipe end to end by the Thermit process of welding, Thermit is used only as a heating agent to bring the pipe ends, which have been previously faced and brought together, up to a welding temperature, when they are then forced together by means of a special hand operated clamping device of simple design, thus making a forged weld. This is the real important feature of the Thermit pipe weld and the main reason for its merit as a permanent nonleakable union.

The Thermit steel and slag which are controlled by means of a special two-part cast iron mold enclosing the joint, are discarded after the weld is completed, thus leaving no foreign material, which might be of a more or less porous nature, as an integral part of the joint constructure.

The Thermit process is most commonly used in connection with standard and extra heavy weight pipe up to and including 6 in., and double extra heavy pipe up to and including 4 in. The rate of production varies from twenty to fifty joints a day, two men working, depending upon the size and weight of pipe and facilities for executing the work.

The actual steps in executing a Thermit pipe weld are as follows:

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*Presented before meeting Boston Section, A. W. S., December, 1927.
†District Sales Manager, Metal & Thermit Corp.

The pipe ends are first faced smoothly and squarely by means of a small hand-operated milling tool. A clamp is placed near the end of each pipe and the whole held rigidly together by two draw bolts diametrically opposite after lining up the pipe, so that the faced ends butt and coincide. A two-part cast iron mold parted horizontally through the middle is next placed, so that it encloses the ends of the pipe to be united. A Thermit portion the weight of which corresponds to the size and weight of pipe, is then reacted in a flat bottom crucible and poured into the mold through an opening at the top. The intense heat of the Thermit steel and slag soon brings the pipe ends up to a welding heat, at which time they are squeezed together by tightening the draw bolt nuts one complete turn, which is sufficient to assure a 100 per cent weld.

It will be observed from this description that the personal element enters into the operation only to a slight degree, the whole operation being of a more or less mechanical nature, thereby making the process practically fool-proof and assuring uniform results. It should also be noted that no outside source of power is required, and that the apparatus is light in weight and therefore easily handled. A pipe joint made in this manner is just as strong in every way as the pipe itself.

Thermit prepared for pipe welding is packed in individual waterproof bags. Constituting as it does quantity of heat, the weight varies for the different sizes and weights of pipe.

Generally speaking Thermit pipe welding is peculiarly well adapted for making a high class pipe joint. Up to the present time it has been most generally used in connection with chemical and refrigerating plants, oil refineries, and for high pressure steam hydraulic and compressed air pipe lines.

In closing I wish to repeat and leave with you the following few important features pertaining to welding pipe by the Thermit process, which from a strictly engineering standpoint are essential to the production of uniformly strong welds:

1. The weld is forged.
2. The slight degree to which the personal element enters into the operation makes it fool-proof and assures uniformity of results.
3. Facility with which the work can be executed, due to the simplicity of the operation, portability of apparatus and the absence of any need for outside source of power—all of which make for rapid and economical production.

"Welding for Eternity"*

By A. F. KEOGH†

I HAVE been asked to appear before you, to tell you something of the work being done by my company, as a small integral part of that stupendous monument, the Cathedral of St. John the Divine.

Time will not permit me to describe the Cathedral of St. John the Divine, which stands on the rocks of Morningside Heights. It is located between Cathedral Parkway and 113th Street, Amsterdam Avenue and Morningside Drive.

The grounds called the Close, comprise 11½ acres and cost $850,000. The buildings, other than the Cathedral, cost about $1,000,000. The prevailing style of the architecture will be French Gothic. The plan of the Cathedral will be in the form of a cross.

The loftiest features of the elevation are the two towers of the West Front, and the Great Central Tower above the Crossing, which rise to a height of 500 ft. above the ground.

When completed, the Cathedral will extend from Morningside Drive to Amsterdam Avenue, more than a tenth of a mile. It will be 601 ft. long and 315 ft. wide across the transepts and with an area of 109,082 sq. ft.

The parts thus far built are the Crypt, Choir, Seven Chapels of Tongues, Baptistry and Crossing. The West Front and Nave are in course of construction. The completed portion of the Cathedral has cost over $5,000,000. The total cost of the building will be more than $20,650,000. Time of completion is uncertain, as many things hinge upon this date.

The Cathedral is built to endure through the ages and is not a steel frame structure, but one of heavy masonry, and its physical construction, therefore, must be slow.

Materials Used in the Cathedral

Some interesting figures to show comparisons on amounts of materials used in construction of the Cathedral were compiled and loaned to me by Mr. Youngs, of Jacobs & Youngs, general contractors for the Cathedral of St. John the Divine, and are as follows:

In the foundation alone there is poured 9953 cu. yd. of concrete. To get a conception of the materials used, try to imagine the broken stone used in the concrete, loaded on 5-ton trucks, allowing a 50-ft. space for each truck, which is riding quite close together. The procession would reach 29½ miles. The cement carried under the same conditions 4 3/5 miles and the sand carried the same way, 9½ miles, or a total procession of trucks 43 3/5 miles, or a distance equal to that from the Cathedral to Bear Mountain Bridge. The Nave arches rise from piers 98 ft. high and the center of the span from the floor is 123

*Presented before New York Section Meeting, American Welding Society.
†President, Sound Welding Co., Inc.

ft. The ribs of these arches weigh 250 tons each. The exterior of the Nave has 10,000 tons of granite, and if it were loaded on 5-ton trucks and allowed the same space of 50 ft., would make a procession 19 miles long, or to Harrison, N. Y. The exterior granite is from Peekskill, N. Y., the columns from Sommes Sound, Mt. Desert Island, Me. The dimension granite from Deer Island, Me. The eight piers, each 98 ft., if stood end on end would be 784 ft. high, or the height of the Woolworth Building. The buttresses and piers of the Nave used 150,000 ft. of dimension granite and if loaded on 5-ton trucks, would form a procession 23 2/3 miles, or to Portchester, N. Y. The interior lining of the walls of the Nave is Buff Indiana Limestone, from Bedford, Ind., and if it were possible to load it on a freight train

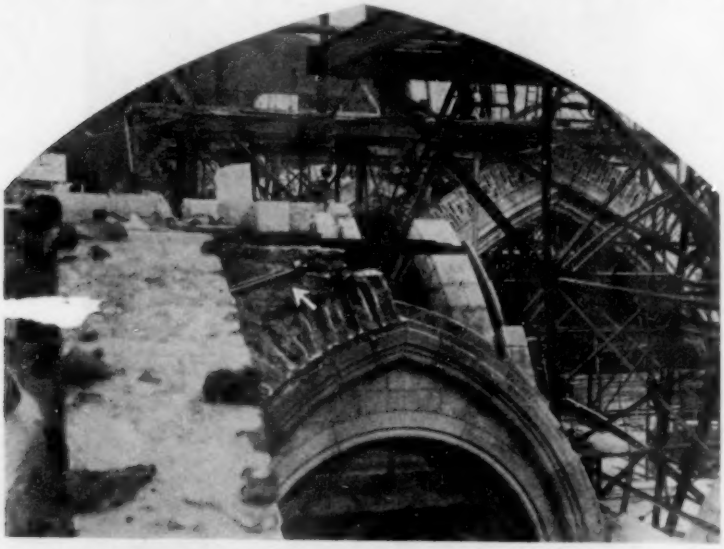


Fig. 1. Snow-melting piping emerging from walls at roof level

and transport it to New York, it would make a fully loaded freight train 5 miles long. Between the inside and outside walls of the Nave there would be 16,888 cu. yd. of Rubble Stone, which would fill 5629 motor trucks and make a procession 53 miles long; 5600 tons of brick another 5¼ miles; sand to fill 2225 more motor trucks an additional 21 miles to the procession, and cement, 980 trucks with 9¼ miles more, making a total procession of motor trucks for this material alone, 88½ miles. If you will try to conceive the amounts of materials going into this structure, then also realize the amount of labor kept moving from the quarries to the stone yards, to the job and all the intermediate hands that handle and prepare it, involving over 1000 men.

Welded Pipe Specified

Just about three years ago, we started work on the floor of the Nave, and laid in the first pipes in steel troughs in snake-like fashion, through the floors of this magnificent building. I can never put into

words my feelings, when I think the wonderful confidence and faith that the architects of Cram and Ferguson had, to specify, welding of pipes and burying them in this massive masonry, where they never can be accessible for repairs, until the end of time. I take this public opportunity of personally thanking these architects, and those who accepted their specifications of welding, for their confidence in allowing this type of welded construction to be used in this magnificent structure.

When the Crossing and Crypt and Seven Chapel of Tongues, which are the older parts of the Cathedral, were built, Vanstone joints were

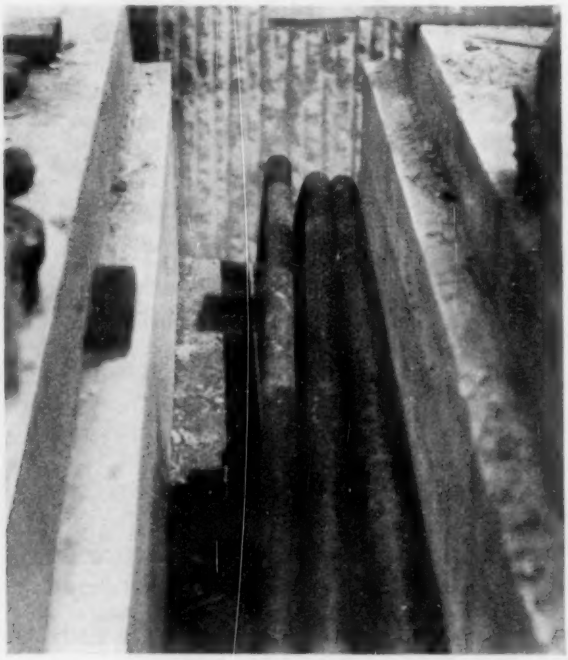


Fig. 2. Piping in the foundation of the west front

used in the pipe fittings. As the heating pipe issue is very insignificant in this part, and I believe only temporary, it will probably be changed some day to welded construction. Of course, in the welded construction, there is no fear of pipes springing leaks in joints, and especially where double extra heavy wrought iron pipes are used. Another point is, that the expansion joints are done away with.

Heavy Weight Pipe Used

All the pipes in the work carried on by us consist of various sizes from 1½ in. to 4 in., inclusive, and a point to bear in mind at all times, is that the pipe is four X extra heavy with the walls of the pipe as follows:

1½-in., the wall about ½ in.
2-in., the wall about ⅝ in.
2½-in., the wall about ¾ in.
3-in., the wall about ⅞ in., and 4-in., the wall about 1 in.

You can imagine how many years it will take for corrosion to do damage to this pipe internally.

The outside of the pipe, as welding of the joints is completed, is treated to a heavy coat of asphaltum and this covered with asbestos as

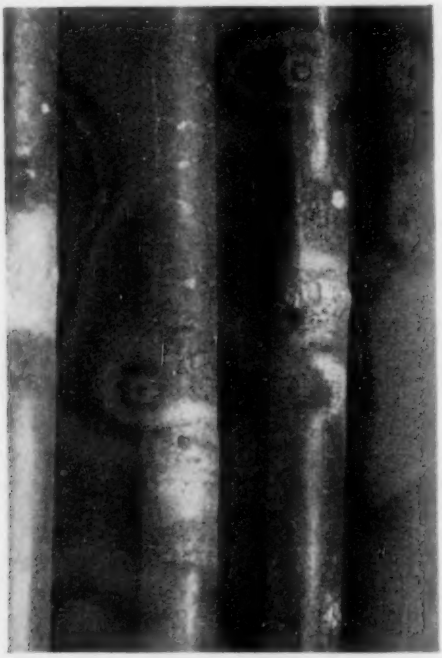


Fig. 3. Some of the welds

insulation, and then all is wrapped in tar paper and again treated with asphaltum. The pipes are already beveled as shown in photo, when they arrive from the pipe company.

They are then butted together, allowing a 45-deg. bevel for welding. The weld is made by getting fusion at the abutting point and carrying the weld around the pipe and outward to the full size of the pipe, then adding welded metal to get a full reinforced weld. When a bend is needed to carry the line in a different direction, the bend is also made in the field, as shown in the photo.

Large Amount of Welding

In the Nave in both the South and North walls, we have located eight sets of pipes in each wall, making a total of sixteen sets comprised of the following:

Eight 3-in. pipes for steam heat, which are imbedded in the walls in heavy hangers, which in turn are imbedded in the masonry, and eight 1½-in. pipes for returns. These rise to the 63-ft. level and serve the radiators which are concealed from view up there in the bays. Eight 2½-in. steam pipes used for snow melters, which run up through the wall, the first dropping off at the 47-ft. level, the second to 98 ft., the third to 135-ft. level. This is unique construction, since each set

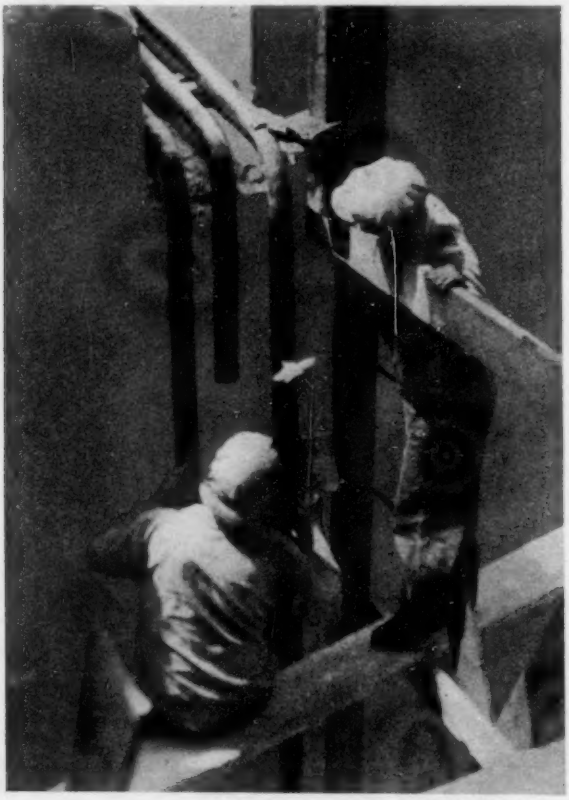


Fig. 4. Welding at foundation level

of pipes runs parallel to an 8-in. copper pipe and keeps them from freezing.

These copper pipes are the down spouts or rain pipes to carry rain and snow water from the roofs of the Cathedral. The snow risers are run to their proper level and a tap is made and a perforated pipe laid in the gutter to emit steam to melt the snow and ice. Also on the top of the copper pipe is installed a heavy brass mushroom strainer. In the center of this strainer, starting about 8 in. inside the copper pipe and running up to the top of the strainer, is another perforated pipe to keep the strainer and pipe free of ice and snow.

In the West Front we have seventeen groups of pipe composed of the following:

Three 4-in. and three 3½-in. for steam mains.
Fourteen 2½-in. for snow risers.
Four 1¼-in. for returns, making a total of 27 risers in the West Front.

When one realizes that these pipes are imbedded in the center of from 8 to 14 ft. of solid masonry, weighing hundreds of tons, is it any wonder we keep feeling a debt of gratitude to these architects who so boldly advocated concealed pipe and welded construction.

There is a certain feeling of pride and satisfaction in having the honor to work on a project of this kind, and I do not believe there is any one connected with this wonderful work, who is not imbued with this feeling, from the architects and engineers, who have their whole hearts in this job, all the way down the line. The feeling is contagious.

I feel certain in saying, it will not be long before the mass of architects and engineers grasp this feeling of security of Cram & Ferguson, Jacob & Youngs, and the Cathedral authorities, to follow in their example and specify all welded construction to endure.

In giving my paper the title, "Welding for Eternity," I might be criticized, but feel absolutely safe in saying that the best in architectural and engineering talent was employed in the design and fabrication and this Cathedral is built to endure down through ages, and so the welding and the pipe must also endure.

Electric Welding of Structural Steel and Ornamental Iron*

PAUL B. COVEY†

I FULLY realize that my topic for this evening is getting to be a rather common-place one—for "welding of structural steel and ornamental iron" is by no means the novelty that it was some two years or even one year ago. There is hardly a meeting on welding held nowadays that this phase is not brought up and discussed pro and con.

In order to indicate the wide range of applications of welding in this field I will give below a number of examples of such applications.

Fire Escapes

Completely welded fire escapes except for a few field connections which are bolted, have been completed in a number of places in Nashua and Claremont, N. H. See Figs. 1, 2 and 3. In the fire escapes we weld 3-in. channels to the edges of the gratings, these channels resting on and connecting to the brackets. Treads are welded to the stringers.

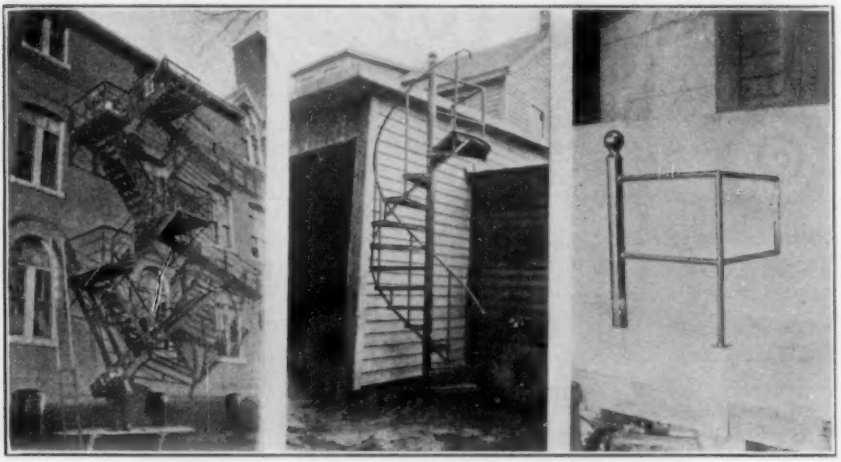
*Presented before Boston Section Meeting, A. W. S., October 21.
†Proprietor, Manchester Engineering & Welding Company.

Ladders

The rungs are made of ½-in. pipe cut to length and welded to side bars. This makes a rung about ⅞-in. outside diameter. The use of pipe instead of solid rods lightens the weight of the ladder.

Racks

These racks were about 4 ft. wide and 19 ft. long, the long bars being 4 x ⅜ set on edge and about 3 in. center. Considerable difficulty was experienced in preventing distortion due to welding. After a



Figs. 1 to 3. Welded fire escapes

great deal of experimenting we managed to make the last one perfectly straight in all directions. In order to accomplish this end it was necessary to warp the long bars, about 1½ in. in the opposite direction, to which they would normally bend and the cross bars about ¼ in. Then everything was securely bolted together with this material distorted like this, and all joints welded up. When cold we removed the bolts, wedges, etc., and the material all sprang back to a straight position.

After completing these we had three other racks to make quite similar and, profiting by our experience with these, we were able to make them all straight the first time we tried.

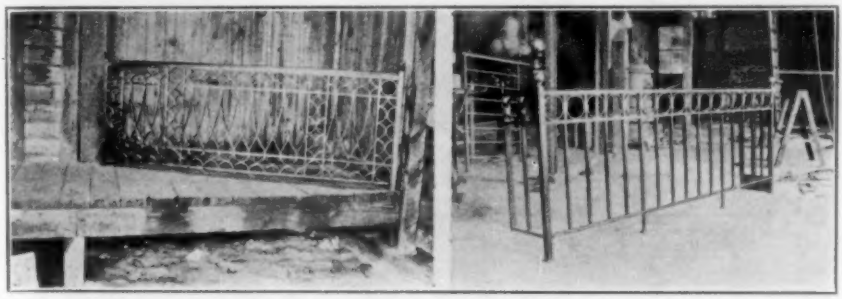
Other Applications

Sky Light Frames and Frame Work and Window Guards for a Reform School.

Ornamental Railing. Two types are shown in Figs. 4 and 5.
Runways for Automobiles.
Door Openings in Floors.
Door Jambs.
Variety of Structural Work.

In Figs. 6, 7 and 8 are shown views of one of twenty-two roof trusses furnished for the Courier Art Gallery in Manchester. The number of inches of welds deposited are indicated by numbers on the photograph. The sketches show the full truss with particular panel point marked with a circle. Before putting an operator on important work we require him to make up a set of test pieces similar to that shown in Fig. 9. These are tested to destruction and from the results of these tests we design all welded connections on which this particular operator is to work.

In designing the number of inches of weld to deposit we used 1500 lb. per lineal inch of ¼-in. fillet weld and then nearly doubled the amount of calculated length—giving us from 8 to 10 for a factor of safety. We were particularly anxious that these trusses were perfect when they left our shop and we did not wish to take any chances.



Figs. 4 and 5. Ornamental iron railing

The roof is now installed complete and the trusses are still standing, although, of course, they have not yet taken any snow loads.

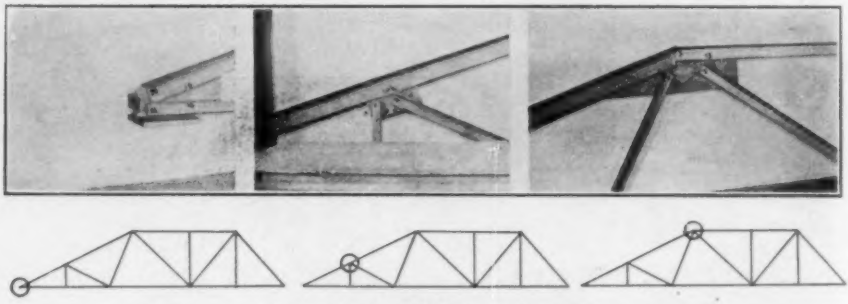
I might say that the cost of these trusses when completed came to about 5¾ cents a pound. We saved about 18 per cent in the weight through a redesign of the trusses which, based on current prices up our way, would mean a net saving in cost of about 2½ per cent. We think this is very good, as it was our first job of trusses and would naturally cost more than our next set would cost.

Welding versus Riveting

I shall not take your time this evening to discuss the many general advantages which electric welding has over riveting because they have been presented so many times they are familiar to all of us. I refer to saving in cost of shop drawings, in making shop lay-outs, in shearing of plates and angles and in punching and drilling of holes. These and many other things are real advantages at the present time. However, as time rolls on and competition becomes more and more keen, many of these arguments will lose their value for, with competition will come a necessity for greater care in design and in fabrication. Let me illustrate. I referred a few minutes ago to my using a factor of safety of nearly 10 in the designing of the joints of the roof trusses.

That is all very well now where I am up against practically no competition—but as other concerns start using this method of fabrication and their prices begin to approach my "cost" figures, it will be more and more necessary for me to assure myself of just how far I can go with safety and still meet the demand for price.

It is all right for me now to say, "I must deposit 14 in. of weld to properly connect the angles to this gusset plate, but to be more than sure of myself, I will call for 25 in." But I appreciate that later there will be a different story to tell and I am wondering whether there will not be just as much care required in the designing and the laying out of welded joints as of riveted joints. But granting that this time *will* come, I firmly believe that electric welding will *still* win out in competi-



Figs. 6 to 8. Welded roof trusses

tion with riveting in many of the branches of the fabrication of structural steel and ornamental iron.

I have read with a good deal of interest an abstract of the address presented by Mr. Edwards of the American Bridge Co. before the American Iron & Steel Institution at New York, on the fabrication of the five-story steel frame building erected by the Westinghouse people. This, we might say, is a mighty discouraging report—for in most of his data welding seems to lose out and when he closes with a statement that the net cost was some $4,200 more than it would have been for a riveted structure, it comes pretty close to taking the wind out of a fellow's sails. However, I believe there is no reason for such pessimism. I am reminded of the first fire escape I made. It was a small one, only about 12 ft. high. It was one of the first jobs I had to figure. I was anxious to get work and to get experience and so I gave a wild guess as to cost, estimating it about the same as I would have for a riveted and bolted one. On accumulating my cost data, I found I had exceeded my estimate almost 100 per cent. I at once figured on another and figured on exactly the same basis. I lost on this too, but not as heavily. I figured on another and still another, and now today I am figuring at an even lower rate than I originally did, but with this difference: I am now making good money on each one I turn out. If I had been discouraged at the loss I had at the beginning I would have closed up my shop long ago, but I realized what many others must realize in time, and that is, that when a person starts out to

make something for the first time—whether it is shoes or wheelbarrows or steel buildings—the first one he makes will always cost him money. There must come a careful and persistent study of details of construction, and a continual trying of this and trying of that until the older methods, so well adapted to riveted, are done away with and new ways are devised which are especially suited to welding.

Mr. Matte, associated with Albert Kahn of Detroit, in his paper, "Arc Welding in Building," has reached this same conclusion, for he

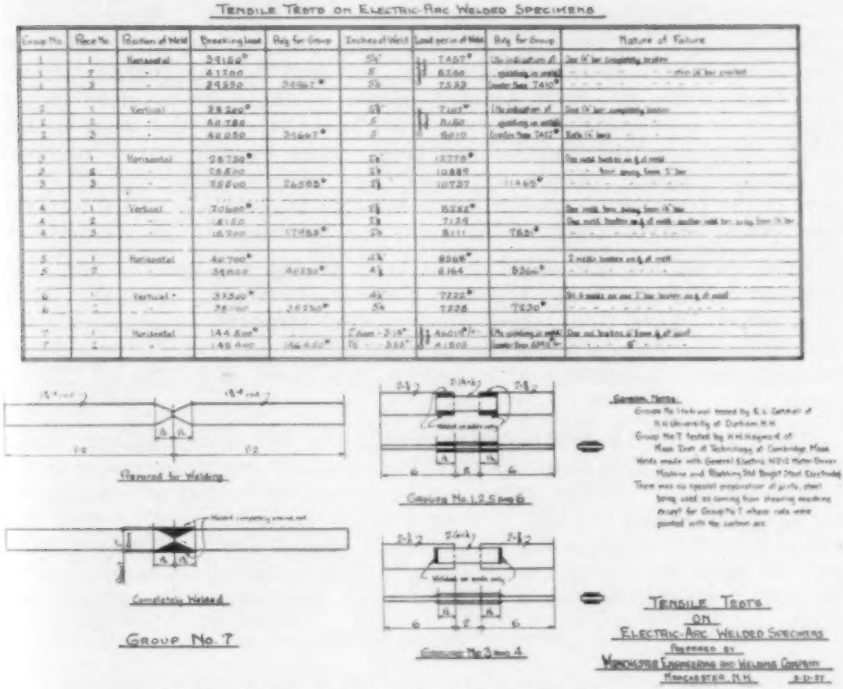


Fig. 9. Tensile tests on electric arc-welded specimens

says: "In the present state of the art, steel welding is more expensive than riveting unless some advantage resides inherently in the welding which offsets or overbalances the extra cost."

Then he goes on to show how he is revising older methods and working up newer ones with the idea of welding consistently before him.

Then, again, Mr. Watson, of the Youngstown Welding Co. of Youngstown, Ohio, in his paper, "Arc Welded Structural Steel Buildings," brings out this same point when he states in referring to a large factory building which they have just erected, that in designing the building he kept in mind the following: "First, to design for welding and disregard all precedent in rivet design."

Structure Should Be Designed for Welding

A careful study of the papers which are being presented from time to time will bring out the fact that where one tries to weld up a structure designed for riveting, the cost is excessive, but where the structure is redesigned for welding and then welded, the cost data are more favorable.

A need which will become more and more apparent as competition increases is a new series of structural and bar shapes especially designed for welding. I have not made any study of this and do not know just what to suggest, but I have a few things in mind.

For instance, if we had tee irons with long stems, they would be very useful in roof truss design for top and bottom chords. If we had bars, rods, etc., with scarfed edges, it would be possible to use them in ornamental design work. We could deposit the weld in the recess caused by the scarfing and thus reduce the labor now required in either grinding off the edge ourselves before depositing the bead —or if the plain bar is used in smoothing up the welds in order to make neat, sharp corners when the different members connect to one another.

Another section which would be very useful for bracing for steel frameworks of all kinds is a bar whose cross-section is in the shape of a cross. This would give good lateral strength in all directions and would be very light for the strength it would give. It would also be very easy to connect this section to almost any type of framework.

These are only a few suggestions hastily brought together, but I trust it may be a nucleus about which a study might be made which will result in the placing on the market of a good variety of new shapes particularly suited for the welding process of fabrication. I feel confident that if there is a real call for new shapes, our steel rolling mills will be glad to furnish the sections. But, naturally, we must make the call first, and before calling we must know what new shapes we really want.

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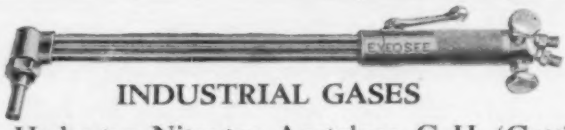

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Do you understand our free loan cylinder plan? If not, we are glad to explain

Supplied in the following size cylinders:

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The efficiency of welding in repairing broken machine parts; in bonding rails; joining structural steel; and countless other uses in the industrial fields, has been definitely proven. To give satisfactory service, the wire must be strong, tough, uniform, and give the least trouble in welding. All of these qualities are found in Roebling Welding Wire

JOHN A. ROEBLING'S SONS COMPANY

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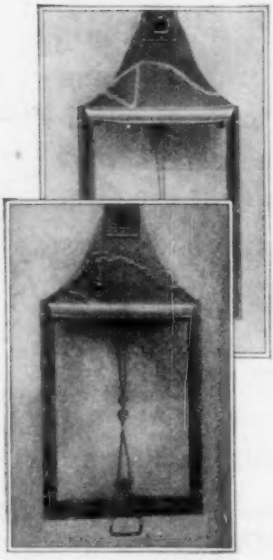
Mention the "Journal of the American Welding Society."

Welding a thin Casting
very difficult to pre-heat



Broken cast iron scale platform welded with Tobin Bronze without pre-heating

ANACONDA

Anaconda Welding Rods are manufactured from the following alloys:

TOBIN BRONZE
SILICON COPPER
PHOSPHOR BRONZE
MANGANESE BRONZE
MUNTZ METAL
SPECIAL ALLOYS

THE danger of cracking and warping prohibited the use of methods involving preheating for the welding of this unsupported cast iron scale platform. By using Tobin Bronze Welding Rods, it was possible to make the repair without pre-heating in a furnace. The low welding temperature required for Tobin Bronze Welding also eliminated the danger of further cracking and reduced the risk of distortion and shrinkage.

Since Tobin Bronze has a tensile strength twice that of cast iron, welds correctly made with this material will not break at the joint. Tobin Bronze permeates the iron and forms a permanent bond stronger than the casting

Many manufacturers who have proved the value of Tobin Bronze Welding for repair work are now using it to save time and money in manufacturing operations.

Tobin Bronze Welding Rods are made solely by The American Brass Company and each rod has the Tobin Bronze trademark rolled in the metal. They may be obtained from leading distributors of welding equipment and supplies.

THE AMERICAN BRASS COMPANY
GENERAL OFFICES: WATERBURY, CONNECTICUT
Canadian Mill: ANACONDA AMERICAN BRASS LIMITED
New Toronto, Ontario

TOBIN BRONZE
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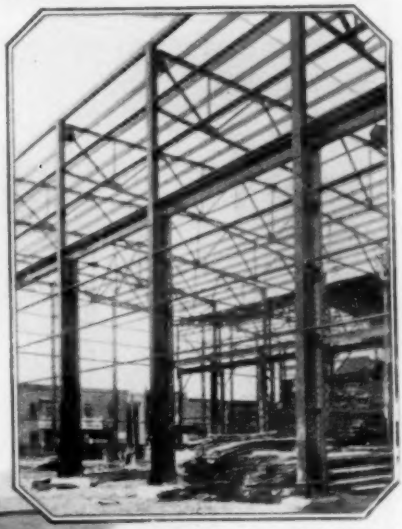
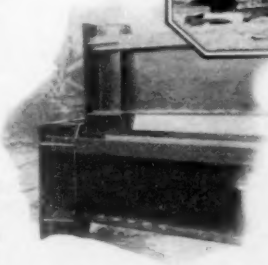
EXCLUSIVELY AN ANACONDA PRODUCT

A Monument of STEEL to the Strength of the WILSON WELD



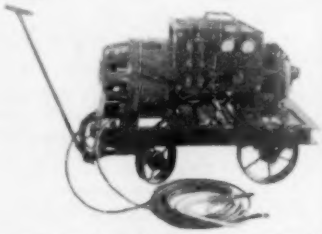


Above—Part of a steel structure which was welded with Wilson Grade No. 17 bare wire.

At left—An example of the arc welding done on large steel girders.

CONTRACTORS and engineers in constantly increasing numbers are choosing electric arc welding for joining structural steel members. Its advantages have been demonstrated. It eliminates the necessity of punching holes and the use of rivets; it eliminates the din of riveting; it dispenses with many overlaps, brackets, and angle connections; it saves steel; it saves time; it saves money. And now in structural steel work, as in practically every other industry, Wilson Welding Wire demonstrates its superiority—its ***uniformity***, its ***smooth flowing*** quality, its ***economy***. There is just the right grade (analysis) of Wilson Wire for each kind of metal, and every grade runs ***uniform throughout***—every rod is exactly like every other rod of the same grade. That makes *perfect* welds possible. "The rest is up to the welder."

No matter what industry you are in, Wilson Welding Wire will meet *your* particular needs. There is the *right grade* of Wilson Wire for the metal you are welding. And there is a Wilson Type S Welding Machine that meets *your* particular operating conditions—a single or two-operator unit, gasoline-engine-driven, belt-driven or motor-driven, with capacities of 25-250, 25-300, 25-600, 50-400, 50-800 amperes. Write today for bulletins describing Wilson Welding Machines, and ask for a sample of Wilson "Color-Tipt" Welding Wire, indicating the kind of metal you wish to weld.



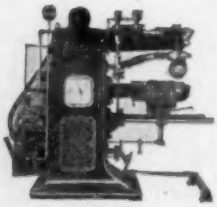
Wilson Type S Single Operator Motor-Driven Machine

WILSON WELDER & METALS CO. INC., WILSON BLDG., HOBOKEN, NEW JERSEY

WILSON

WELDING MACHINES AND WELDING WIRE

SPOT



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ARC

For Production
Electric Welding
Machines

Gibb Welding Machines Company

Bay City, Michigan

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Welding Rod

WELDITE G—No. 6 Coppered Finish for gas welding lays the metal down quietly, free from boiling, free from surface scum and floating white specks. The metal settles instantly when the torch is removed.

WELDITE E—No. 18 Green Surfaced for electric welding is the smoothest running electrode ever offered users of welding. Sold at the price of bare electrodes.

Products of the Research Department

MANUFACTURED BY

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Let Pop Be the Judge at the Trial

"Here, Lad—

you tell me that the fellows in the shop don't like the way this welding rod I buy them is packed and wrapped.

You know, Lad, it's hard to judge a man by his clothes."

"Yes, Pop—

and today it's absolutely impossible to judge a woman that way.

But you CAN judge a welding rod.

Just let me send for some of that Lincoln 'Stable-Arc' BLUE welding rod (non-splashing).

It's judged by its clothes:

A nice BLUE coat.

And the better work it makes the men do proves that it has a good influence on them.

Then it's packed (not wrapped) in steel containers.

The rod gets to our men in the same condition that it left the Lincoln men.

The package is neat—but not gaudy.

The rod does a job that's neat but not splashy.

And no Mid-Victorian maiden aunt was ever better protected from the elements."

A new textbook on Arc Welding (Price $1.50) will be sent on approval for five days to any executive requesting it.

Book size, 6" x 9"—total pages, 160—number of illustrations, 200—Charts, 62—Divisions, 8.

The Lincoln Electric Co., Dept. No., 22-1 Cleveland, Ohio

"Stable-Arc" W-30

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A monthly publication devoted to gas welding and cutting and other uses of the gases produced by this Industry.

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G. H. MATHEWS, Managing Editor

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No matter what your welding problem may be, *The Welding Engineer* is the best source of information available. Its pages discuss, monthly, every phase of welding. One idea from one issue will more than pay for a year's subscription to this valuable publication. The value of the reading matter is assured for the best welding authorities in America are regular contributors.

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H. S. CARD, EDITOR

The Welding Engineer—608 S. Dearborn Street, Chicago, Ill.

Our Advertisers Are Supporting the Society.

Joint Exhibition With Steel Treaters

An Exhibition of welding apparatus and supplies will be held in connection with the Fall Meeting of the Society in Philadelphia, the week of October 8, 1928, as a joint affair with the American Society for Steel Treating. The cooperation of all manufacturers is desired.

INSTRUCTION MANUALS

A set of instruction manuals giving fundamental information for the training of student welders and engineers in Electric Arc, Gas, Resistance and Thermit Welding, has been prepared by an Educational Committee of the American Welding Society.

These are now available in separate bulletin form and also bound together in permanent book binding. The prices are given below:

GAS COURSE	50c.
RESISTANCE COURSE	35c.
THERMIT COURSE	50c.
ELECTRIC ARC COURSE	50c.
BOUND VOLUME ALL COURSES	$2.50

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Leak-proof tanks and pressure vessels—by oxwelding*

ALL riveted storage tanks and pressure vessels develop leaks ultimately. Every year thousands and thousands of dollars' worth of volatile liquids evaporate from storage vessels even though the riveted vessels may appear tight when tested. Oxwelded vessels on the other hand are actually and permanently leak-proof.

That is why oxwelded tanks and pressure vessels have become popular.

A test was made recently on a welded tank five feet in diameter and forty-three feet long, made of inch and one-eighth steel with double-vee oxwelded joints. The vessel was designed on the basis of a fibre stress of 8,000 lb. per sq. in., but when the test pressure was raised to 1,000 lb., the testers were applying a pressure equal to three times the working pressure (based on a design fibre stress of 9,000 lb. per sq. in.). Two tests at this pressure showed practically no distortion except around the manhole. It was then tested to destruction, and failed through the manhole. Examination proved that the welds were in no way affected.

It would be impossible to make such a high proof test on riveted pressure vessels because the riveted seams spring leaks long before the walls or the heads are severely stressed. But it is now possible to test even the head construction and design, since oxwelded joints and seams are as strong as the metal walls themselves.

Linde Procedure Controls explain in detail the construction of pressure vessels with Oxweld No. 1 High Test rod.

THE LINDE AIR PRODUCTS COMPANY
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General Offices: Carbide and Carbon Building
30 East 42d Street, New York

37 PLANTS . . . . . 105 WAREHOUSES

LINDE OXYGEN

* No. 9 of a series of advertisements on the engineering phases of oxy-acetylene welding and cutting. Send for the booklet entitled: "Engineering and Management Phases of Oxwelded Construction."

Portability

Repair jobs do not respect convenience. On one side of the plant there is a steam leak that must be stopped quickly by oxwelding. Or, a machine breaks on the other side of the plant. Again a hurry call for the welder. Time after time oxwelding equipment must be transported with speed.

Then the convenience of moving a cylinder of Prest-O-Lite dissolved acetylene becomes apparent. The WK cylinder contains about 270 cubic feet of gas and weighs much less than even the smallest welding type generator; the WC size (100 cu. ft. capacity) offers a still greater factor of portability. That is why cylinders are always used where portability is essential.

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DISSOLVED ACETYLENE

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Now—

Three Master Welders

A Distinct Type of

Single Operator Set

for each class of work

The speed in operation, the strength and uniformity of welds, the high efficiency over the entire operating range, "pep" and stability, and the low maintenance costs that characterized Westinghouse Welding Sets in the past, are embodied in three new machines—plus mechanical features which the rapidly increasing use of electric arc welding demands.

So now there is a complete line of welders available—distinct types of single operator sets for each class of work—ranging in capacity from 200 to 400 amperes.

These sets represent the latest development in welding machinery. The entire range of each machine is obtained by merely turning a single rheostat handle. They are all equipped with Linestart Motor and Linestarter—a simple and economical combination. Just push the button and the Linestarter functions, the motor starts and the machine is in operation.

The generator instantly responds to any change of voltage in the arc. The design of the Westinghouse Welding Generator assures a fast, dependable machine—one that assists the operator to do more and better work.

200 Ampere

This unit will operate over a wide range from 60 to 300 amperes, which is the range ordinarily required in general welding service. It has a rating of 200 amperes for one hour, high continuous capacity.

300 Ampere

Has a welding range of from 75 to 400 amperes. This increased capacity enables operators to handle heavy work in addition to average welding work, and is recommended for automatic service. It has a definite rating of 300 amperes for one hour, high continuous service.

400 Ampere

Designed and constructed for extra heavy work in addition to average welding work, and for automatic service where high current and speed is desired. This unit has a welding range of from 100 to 500 amperes and has a definite rating of 400 amperes for one hour, high continuous capacity.

Westinghouse Electric & Manufacturing Company

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If You Want to Know Why

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IN WORKMANSHIP
WHERE
SKILL AND GOOD TOOLS MEET.

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Railway
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In the Steel Mills

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Practically, the majority of the modern steel mills have found Thermit to be indispensable in the reclaiming of broken iron and steel sections of every description.

They have found it efficient and economical to install Thermit reclamation departments in which table rolls, rolling mill housings, blooming engine parts, crankshafts, connecting rods, charging peels, pinion teeth wabblers, and other broken and worn sections can be repaired in a minimum time.

This eliminates the necessity of carrying numerous replacement parts and the danger of expensive shutdowns. A Thermit reclamation department pays handsome dividends. Let us explain it in detail.

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A typical Thermit reclamation job—New Pods Thermit welded on wabbler end of a cast iron roll—showing Pouring Gates and Risers

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AMERICAN WELDING SOCIETY
33 WEST THIRTY-NINTH STREET
NEW YORK, N. Y.

.....192..

Secretary:

I hereby apply for Membership in the AMERICAN WELDING SOCIETY as a ..... Member and attach
(Note Grades on other side)
hereto remittance of $..... for first annual dues. Remittance will be refunded in the event of rejection of applicant. I also agree to abide by the Constitution and By-Laws of the Society.

Name .....

Present occupation .....

Name of Company and Address .....

Residence .....

Address for mailing .....

Applicant is requested to state here length of welding experience and processes involved, also to record any technical or mechanical experience or special interest in the welding field.

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References: (1. .....

(at least two) (2. .....

Proposed by .....

(See other side)

CUT OFF ALONG THIS LINE

QUALIFICATIONS FOR MEMBERSHIP

Extract from By-Laws

ARTICLE I.

Section 1. Individuals having received the approval of a majority of the Membership Committee shall become members of this Society upon the payment of dues, except in the cases of honorary members who shall be elected by unanimous vote of the full Board of Directors.

Section 2. Membership shall be divided into five classes:

Sustaining members, being individuals or individuals delegated by corporations, firms, partnerships, etc., interested in the science and art of welding, with full rights of membership.

Annual dues..... ..... $100.00

Members, being individuals interested in the science and art of welding, with full rights of membership. Engineers or individuals competent by experience or training to plan or direct welding operations are eligible to this class.

Annual dues..... $20.00

Associate members with right to vote but not to hold office, except in Sections as may be provided for by the By-Laws of the Section. Supervising welders, inspectors and skilled operators, with three or more years' practical experience in welding, are also eligible to this class.

Annual dues..... $10.00

Operating members, who are welders or cutters by occupation, without the right to vote or hold office except in Sections as may be provided for by the By-Laws of the Sections.

Annual dues, United States and Canada $5.00
Other countries..... $10.00

Student Members, who are actually in attendance at any one of the recognized colleges and approved trade schools, without the right to vote or to hold office except in sections as may be provided for by the By-Laws of the Section.

Annual dues..... $2.50

You can prove the value of Page-Armco Welding Wire and Electrodes for yourself and your own job.

Careful tests will show you that this carefully processed and thoroughly shop tested wire gives better welding results. What is more, it costs less to use when you figure complete welding costs of time and material. Workmen will tell you Page-Armco Welding Wire is easier to use. It will pay you to investigate.

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Bridgeport, Connecticut

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PROCESSED

Welding Wire *and* Electrodes

An Airco-Davis-Bournonville

Welding Torch

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Combining all Essentials of Efficiency
Including Low Initial Cost
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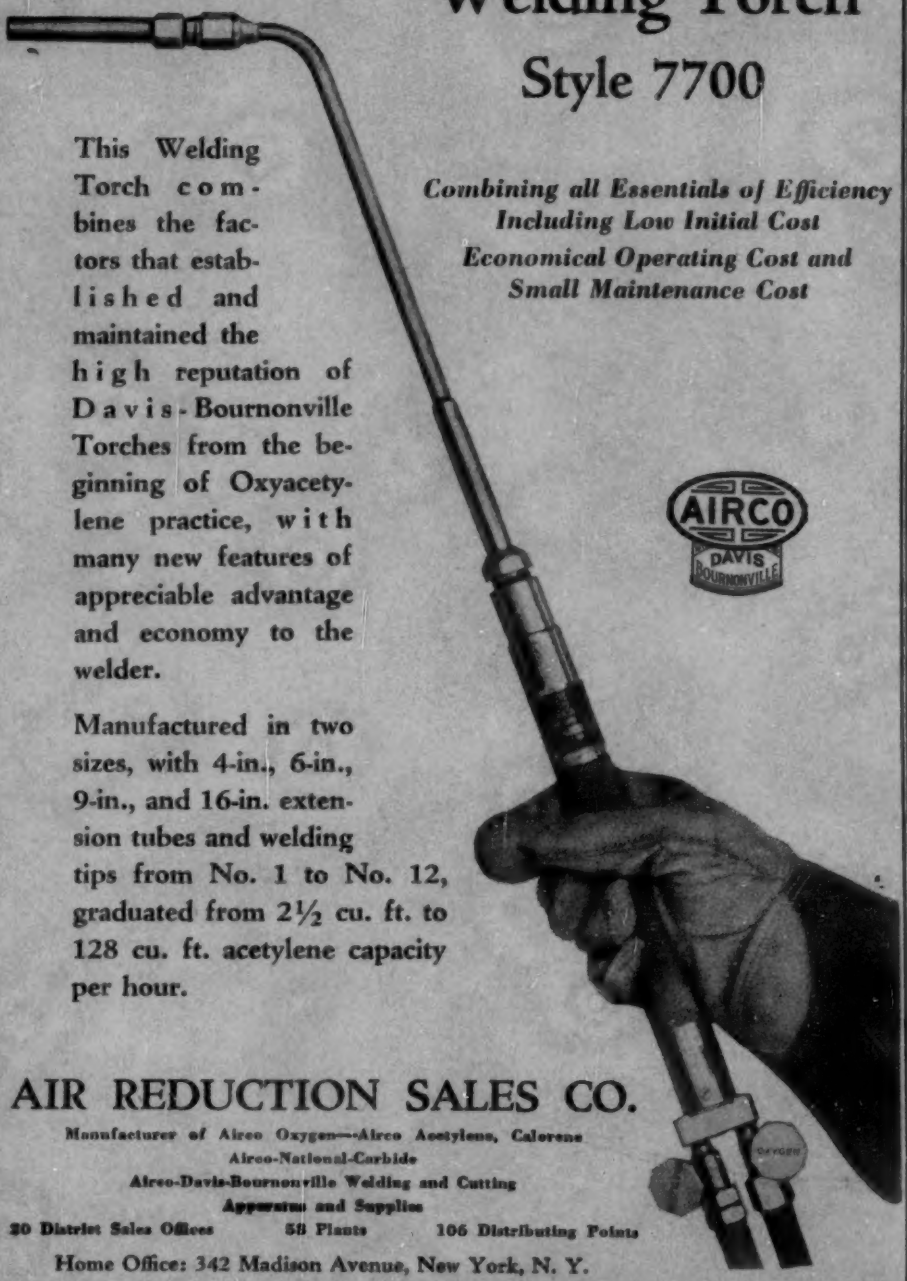

This Welding Torch combines the factors that established and maintained the high reputation of Davis-Bournonville Torches from the beginning of Oxyacetylene practice, with many new features of appreciable advantage and economy to the welder.

Manufactured in two sizes, with 4-in., 6-in., 9-in., and 16-in. extension tubes and welding tips from No. 1 to No. 12, graduated from 2½ cu. ft. to 128 cu. ft. acetylene capacity per hour.

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